R.D. SINELNIKOV

ATLAS OF HUMAN ANATOMY

IN TREE VOLUMES

VOLUME II Part 1

The Science of the Viscera and Vessels

MIR PUBLISHER
MOSCOW

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IN THREE VOLUMES

Volume II

The Science of the Viscera and Vessels

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by
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MIR PUBLISHERS
MOSCOW

First published 1989
Revised from the 1979 Russian edition

Printed in the German Democratic Republic

На английском языке

ISBN 5-03-000324-X
5-03-000322-3

CONTENTS

ABBREVIATIONS AND SYMBOLS

A., a., Aa., aa.—arteria, arteriae.
V., v., VV., vv.—vena, venae.
M., m., Mm., mm.—musculus, musculi.
Lig., lig., Ligg., ligg.—ligamentum, ligamenta.
Gl., gl., Gll., gll.—glandula, glandulae.
N., n., Nn., nn.—nervus, nervi.
R., r., Rr., rr.—ramus, rami.
S., seu, sive—or.
C_1, C_2, C_3—first, second, third cervical nerve ...
Th_1, Th_2, Th_3—first, second, third thoracic nerve ...
L_1, L_2, L_3—first, second, third lumbar nerve ...
S_1, S_2, S_3—first, second, third sacral nerve ...
Constantly present nerve segments are put in round brackets, e.g. (C_1, C_2), (Th_1, Th_2).
Inconstantly present nerve segments are put in round brackets which are enclosed within square brackets, e.g. [C_1(C_2)-C_7(C_8)].
($^1/_1$), ($^1/_2$), etc. in the captions show the proportion of the size of the drawings to the natural size.

THE SCIENCE OF THE VISCERA
SPLANCHNOLOGY

Splanchnologia

Splanchnology *(splanchnologia)*[1] is the scientific study of the internal organs, or **viscera** (*viscera* s. *splanchna*). The term viscera is applied to organs contained in the cavities of the body (the mouth, the neck, chest, abdomen, and pelvis). The viscera are united into systems, or apparatus, according to functional, topographo-anatomical, and genetic properties. Each organ of a given system has its own specific structure and function but takes part in accomplishing the general function of the system together with its other organs.

The **digestive system** (*apparatus digestorius* s. *systema digestorium*), the **respiratory system** (*apparatus respiratorius* s. *systema respiratorium*), the **urogenital system** (*apparatus urogenitalis* s. *systema urogenitale*), and the **endocrine**, or **ductless glands** *(glandulae sine ductibus)* are related to the viscera.

Some of the internal organs are related to various systems. For instance, the **pharynx** is an organ of both the digestive and the respiratory apparatus, whereas the **male urethra** *(urethra masculina)* is a part of the urinary system and is related at the same time to the system of the genital organs.

All the systems of the viscera have a feature in common. They are hollow (cavitary) organs, tubular or of some other shape, which are lined with a **mucous coat**, or **membrane** *(tunica mucosa)* which is covered by epithelium and consists of a **lamina propria mucosae** and **lamina muscularis mucosae**. Within the mucous coat lie many differently shaped **glands** *(glandulae)* secreting mucus into the cavity of the organs. Directly over the mucous coat is the **submucous coat** *(tela submucosa)* and next comes the **muscular coat** *(tunica muscularis)* of smooth muscle fibres. The hollow organs may be covered on the outside by a **serous coat** *(tunica serosa)* or **adventitious coat** (*tunica adventitia* s. *fibrosa*). Between the muscular and serous coats lies the **subserous coat** *(tela subserosa)*.

The listed coats have individual morphological features in each organ, which is determined by the functional trend of the given system of the viscera.

Besides the hollow organs the system of internal organs also contains organs of glandular structure, **glands** *(glandulae)*. These are the salivary glands, the liver, the sexual glands, the ductless glands. They are formed of **parenchyma** *(parenchyma)* which is a specific tissue accomplishing secretory and hormonal function, and of **stroma** *(stroma)*. The stroma is a supporting tissue of the gland and separates it into **lobules** *(lobuli)*. Ductless (endocrine) glands and glands with ducts (exocrine glands) are distinguished. According to structure, the latter are divided into alveolar (acinous), tubular, and mixed alveolar-tubular glands.

It should be pointed out that the activity of all viscera is closely interrelated and their study according to the separate systems (apparatus) is extremely conditional.

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[1] English equivalents to the Latin terms are given according to the Birmingham Revision (BR) of the Paris Anatomical Nomenclature (NA) (Butterworths Medical Dictionary, 1978, second edition, Editor-in-Chief MacDonald Critchley).

THE DIGESTIVE SYSTEM (THE DIGESTIVE APPARATUS)

Systema digestorium
(Apparatus digestorius)

The first part of the digestive system is the **cavity of the mouth** *(cavum oris)* opening on the face by means of the **oral fissure** *(rima oris)*. Next come the **oropharyngeal isthmus** *(isthmus faucium)*, the **pharynx**, the **oesophagus**, the **stomach** (*ventriculus* s. *gaster*), the **small intestine** *(intestinum tenue)*, and the **large intestine** *(intestinum crassum)* terminating by the anus. The **salivary glands**, the **liver** *(hepar)*, the **gall bladder**, and the **pancreas** (Fig. 402) also belong to the digestive system.

THE CAVITY OF THE MOUTH

The **cavity of the mouth** *(cavum oris)* (Figs 402, 403, 429) is the beginning of the digestive system. It is bounded anteriorly by the lips, superiorly by the palate, laterally by the cheeks, and inferiorly by the tongue and muscles forming the floor of the cavity. The cavity of the mouth communicates posteriorly with the pharynx by means of the **oropharyngeal isthmus** *(isthmus faucium)*.

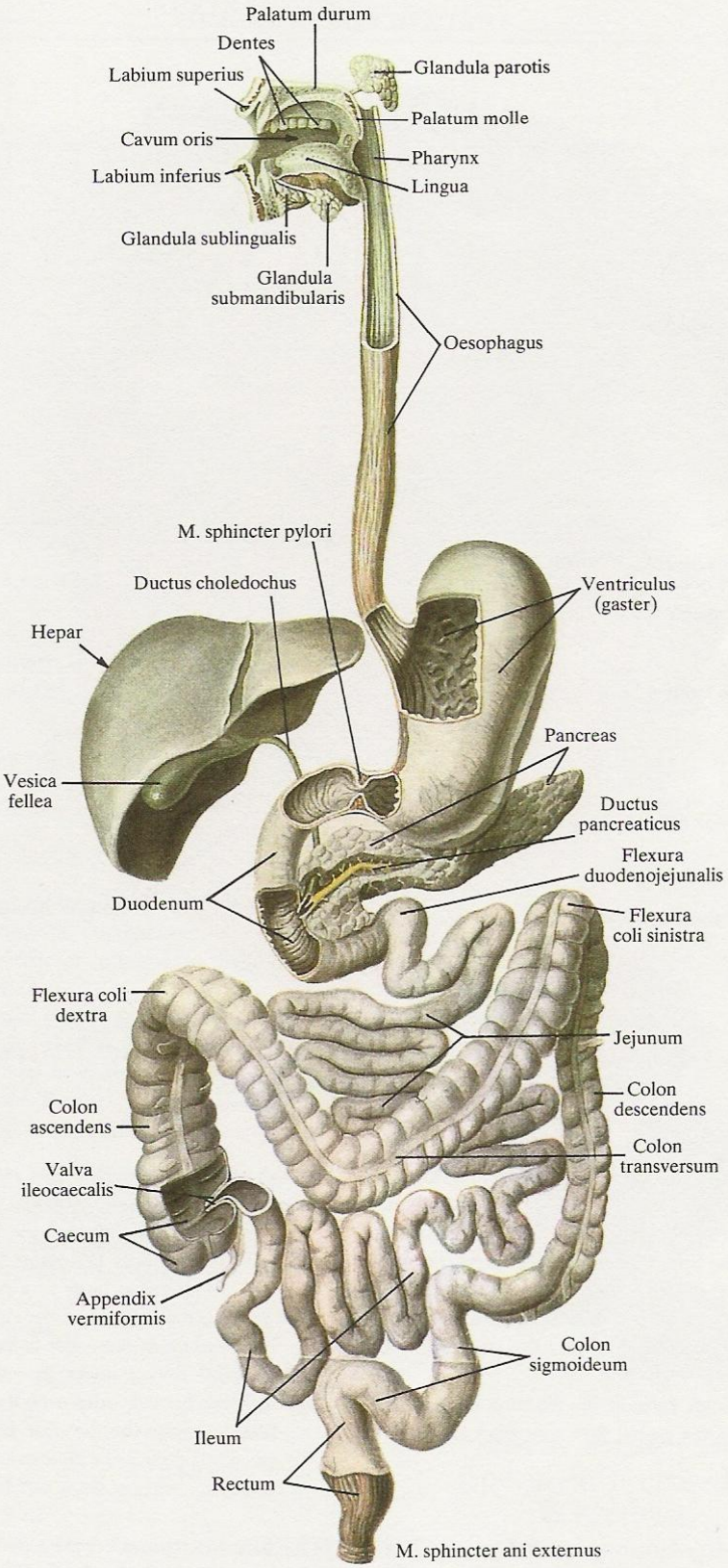
The alveolar process of the maxilla and the alveolar part of the mandible with the teeth divide the cavity of the mouth into two parts: an anterolateral part, the **vestibule of the mouth** *(vestibulum oris)* and a posteromedial part, the **cavity proper of the mouth** *(cavum oris proprium)*. When the teeth are in occlusion both parts communicate by means of small spaces between the crowns of the teeth and large spaces between the last maxillary and mandibular molars.

THE LIPS

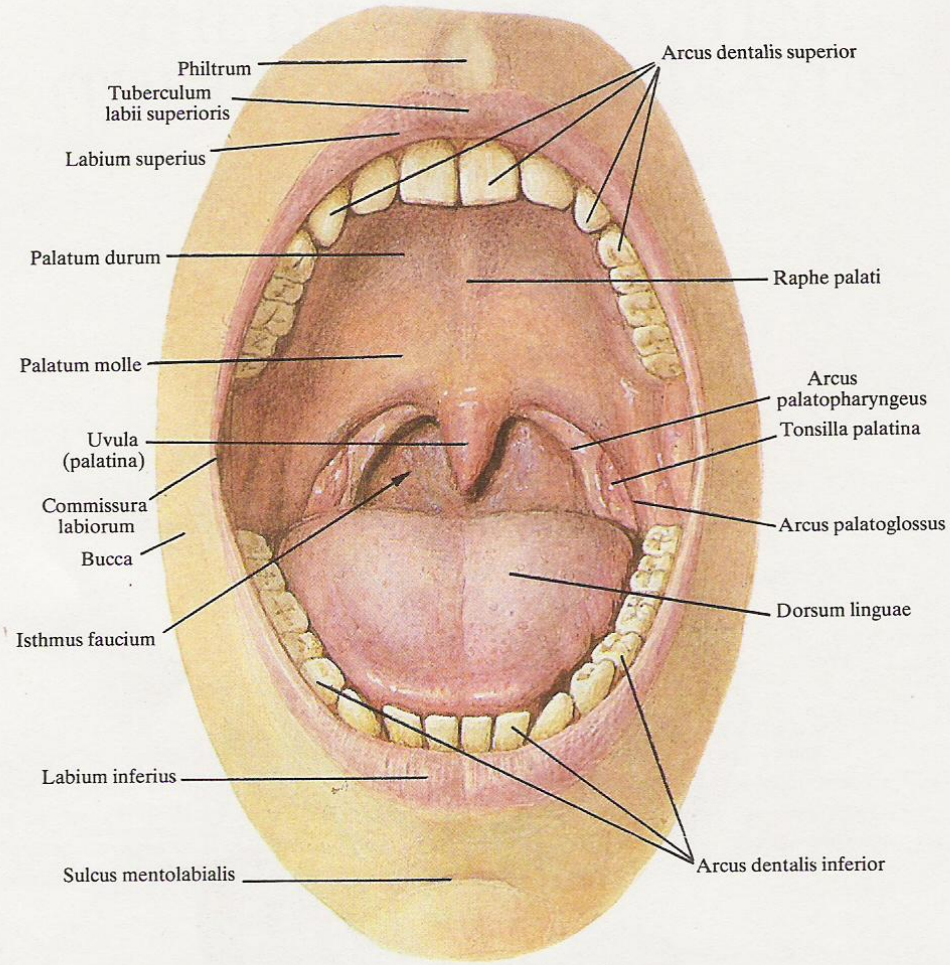
The **lips** *(labia oris)* (Figs 403, 429) are two, for the most part muscular, folds called the **upper lip** *(labium superius)* and the **lower lip** *(labium inferius)*. When the lips are brought together, they close the mouth and form the **oral fissure** *(rima oris)* whose ends are called the **angles of the mouth** *(anguli oris)*. The visible part of the lips is covered with skin which is continuous with the mucous membrane covering their posterior surface. The lips are mainly formed by the orbicularis oris muscle, loose connective tissue, skin, and mucous membrane.

On the skin surface of the upper lip an unpaired median groove descends between two skin ridges. It is called the **philtrum** and terminates at the **tubercle of the upper lip** *(tuberculum labii superioris)*.

The upper lip is separated from the cheeks by the **nasolabial groove** *(sulcus nasolabialis)*. The lower lip is separated from the chin by a horizontal **mentolabial groove** *(sulcus mentolabialis)*. The upper and lower lips are joined at both angles of the mouth by the **labial commissures** *(commissurae labiorum)*.



402. *Digestive system, or digestive apparatus (systema digestorium s. apparatus digestorius).*
Schematical representation.



403. *Cavity of mouth (cavum oris) and oropharyngeal isthmus (isthmus faucium);* anterior aspect ($^1/_1$).

The surface of the lips facing the teeth is smooth, moist, and is continuous with the mucous covering of the alveolar processes, the **gums** *(gingivae)*.

The structure of either lip consists of three parts: (a) the **cutaneous part** *(pars cutanea)*; (b) the **middle part** *(pars intermedia)* which also has a cutaneous covering but without a horny layer; (c) the **mucous part** *(pars mucosa)* occupying the posterior surface of the lip.

Two sagittal median folds form at the junction of the mucous membrane of the lips with the gums; they are called the **frenulum of the upper lip** *(frenulum labii superioris)* and the **frenulum of the lower lip** *(frenulum labii inferioris)* (Fig. 408).

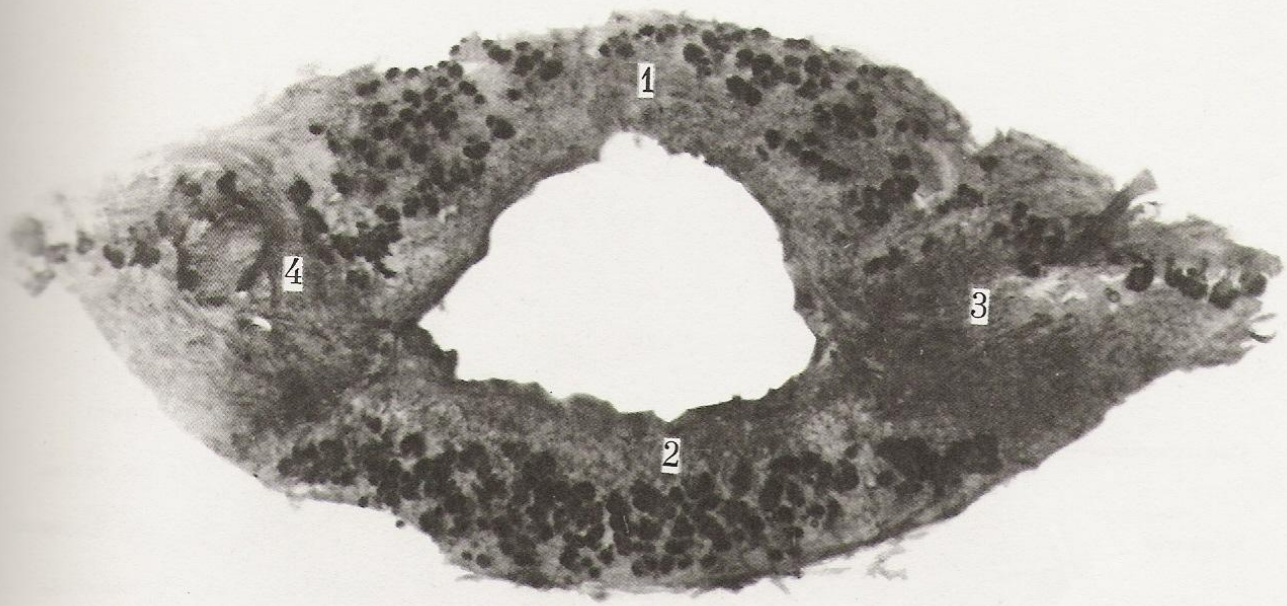
The submucous layer of the lips contains a great number of mucous **labial glands** *(glandulae labiales)* (Figs 404 A, 404 B, 412) some of which are as large as a pea. Their ducts open on the surface of the mucous part of the lips.

Innervation: motor—the facial nerve; sensory: upper lip—the infra-orbital nerve; lower lip—the mental nerve; angle of the mouth—the buccal, infra-orbital and mental nerves.

Blood supply: the superior and inferior labial arteries, mental artery.

THE CHEEKS

The **cheeks** *(buccae)* are covered with skin outside and the **mucous membrane of the mouth** *(tunica mucosa oris)* inside, between which lies the **buccinator muscle** *(musculus buccinator)* (Figs 405, 406, 430).



404A. *Labial and buccal glands (glandulae labiales et buccales)* (specimen prepared by E. Kovbas). (Photograph of totally stained preparation of the lips and cheeks.)

1—upper lip; 2—lower lip; 3—left cheek; 4—right cheek.

The more or less developed subcutaneous fat is always thicker in the central parts of the cheeks. Between the masseter and buccinator muscles is a limited accumulation of fat known as the **buccal pad of fat** *(corpus adiposum buccae)*.

A few ducts of the mucous **buccal glands** *(glandulae buccales)* open on the mucous membrane of the cheeks; the bodies of the glands are embedded in the submucous layer and partly between the bundles of the buccinator muscle. Buccal glands situated in the vicinity of the last molar are called **molar glands** *(glandulae molares)*.

On the level with the upper second molar the mucous membrane of both cheeks bears the **parotid papilla** *(papilla parotidea)* with the opening of the **parotid duct** *(ductus parotideus)* (Figs 405, 406). The mucous membrane of the cheeks is continuous with the mucous membrane of the alveolar process of the maxilla and the alveolar part of the body of the mandible.

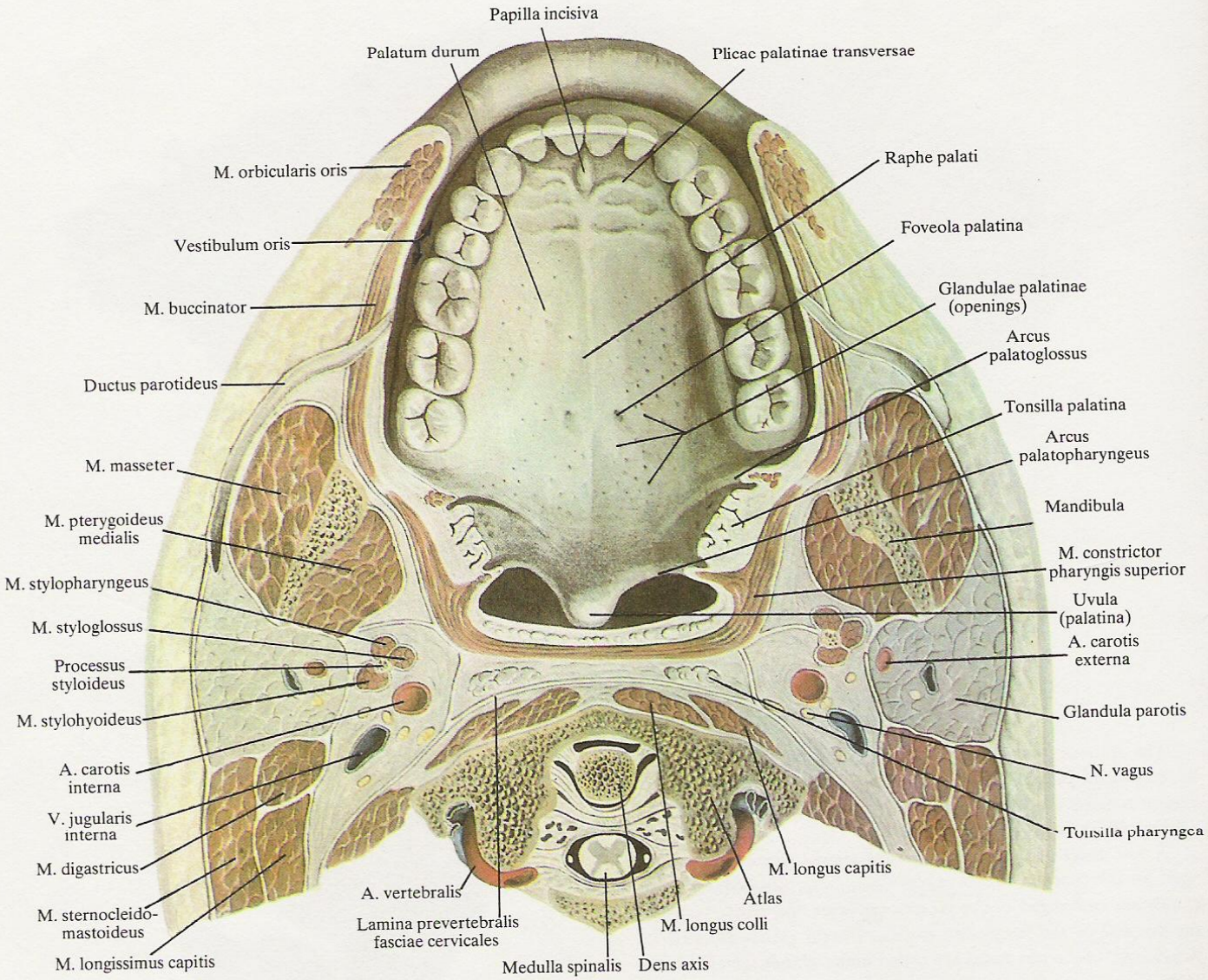
THE PALATE

The upper wall of the cavity of the mouth, the **palate** *(palatum)* (Figs 403, 405, 406, 409), consists of two portions: the hard and soft palate.

The anterior part of the palate has a bone foundation called the **bony palate** *(palatum osseum)*. This is the **hard palate** *(palatum durum)*. Its bony foundation is formed by the palatine processes of

404B. *Buccal gland* (specimen prepared by E. Kovbas). Photomicrograph.

(Isolated gland from a totally stained preparation.)



405. *Cavity of mouth: hard and soft palate (palatum durum et palatum molle);* inferior aspect ($^5/_6$).

(Horizontal section of the head and neck through the level of the first cervical vertebra.)

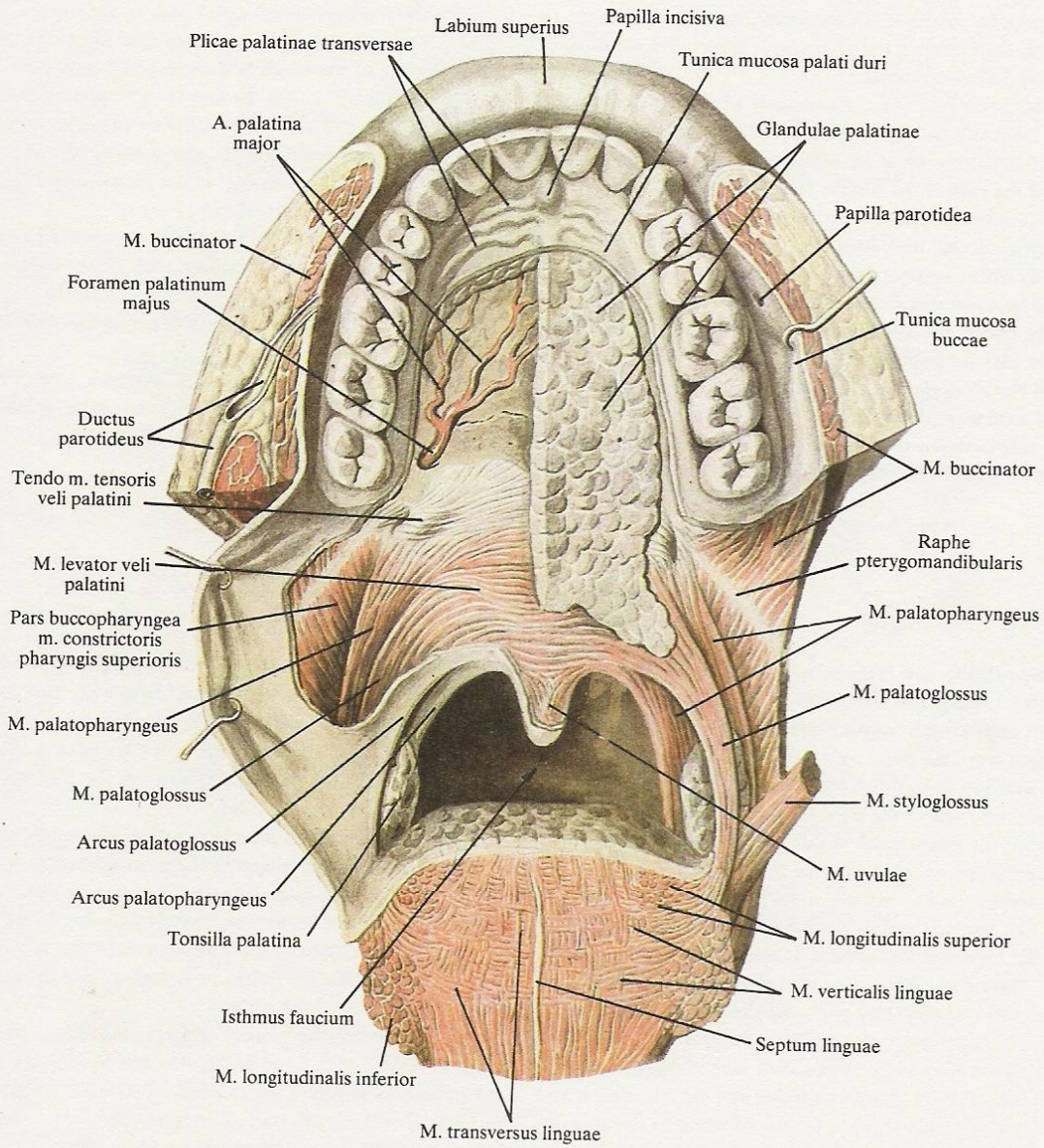
the maxilla and the horizontal plates of the palatine bones. The posterior part of the palate, the **soft palate** *(palatum molle)* is mainly formed by muscles, aponeurosis, and glands.

The mucous membrane fitting closely to the hard palate is smooth and passes over to the gums anteriorly and laterally and to the soft palate, its uvula, and the palatoglossal and palatopharyngeal arches posteriorly. On the midline it bears a narrow whitish streak called the **palatine raphe** *(raphe palati)*. At the anterior end of the raphe close to the medial incisors is the **incisive papilla** *(papilla incisiva)* which corresponds to the **incisive canal** *(canalis incisivus)*.

One or several more or less pronounced **transverse palatine folds** *(plicae palatinae transversae)* arise from the raphe. The mucous membrane is thinner in the region of the raphe than on the periphery. A thin layer of mucous **palatine glands** *(glandulae palatinae)* lies between the mucous membrane and the periosteum (Fig. 406). They form two elongated clusters to fill the depression between the hard palate and the alveolar process of the maxilla.

The layer of glands is thinner in front but thickens to the back where it is continuous with the layer of glands of the soft palate.

The **soft palate** *(palatum molle)* is mostly formed by muscles. An anterior horizontal part, which is a continuation of the hard palate,



406. *Cavity of mouth: the palatine glands (glandulae palatinae) and muscles of the palate and fauces (musculi palatini et faucium)* ($^1/_1$).
(Large part of the palatine mucous membrane and the glands are removed on the right.)

and a posterior part, which stretches obliquely to the back and downwards, are distinguished. The posterior part is called the **velum palatinum** and together with the root of the tongue forms the boundary of the **oropharyngeal isthmus** *(isthmus faucium)*. The velum palatinum projects on the midline to form a small conic **uvula** on whose anterior surface the continuation of the palatine raphe is visible.

On each side the velum palatinum is continuous with two arches. One of them stretches to the root of the tongue and is called the **palatoglossal arch** *(arcus palatoglossus)* (Fig. 403), the other is continuous with the mucous membrane of the lateral wall of the pharynx and is known as the **palatopharyngeal arch** *(arcus palatopharyngeus)*.

Between the palatine arches and the soft palate and root of the

tongue is a space by means of which the cavity of the mouth communicates with the cavity of the pharynx; it is called the **oropharyngeal isthmus** *(isthmus faucium)*.

A thin **triangular fold** *(plica triangularis)* of the mucous membrane arises from the posterior surface of the palatoglossal arch. Its upper part is narrow while its wide base is attached to the lateral border of the root of the tongue. The **tonsillar fossa** *(fossa tonsillaris)* is situated between the posterior margin of the fold and the palatopharyngeal arch; it lodges the **tonsil** *(tonsilla palatina)* (Figs 403, 406) which occupies the fossa completely in adults.

Under the mucous membrane the soft palate contains an aponeurotic sheet called the palatine aponeurosis, as well as some muscles which play an important role in the act of swallowing.

The **tonsil** *(tonsilla palatina)* (Figs 403, 406, 407) is a paired almond-shaped structure which varies in size. The tonsils are situated on either side between the palatoglossal and palatopharyngeal arches, in the tonsillar fossa *(fossa tonsillaris)*. The tonsil borders laterally upon the buccopharyngeal part of the superior constrictor muscle of the pharynx *(musculus constrictor pharyngis superior)*. The medial surface of the tonsil is uneven and has numerous round or oval openings leading into the crypts of its matter; they are called the **tonsillar pits** *(fossulae tonsillares)*. Very many lymph nodules *(noduli lymphatici)* are embedded in the walls of the pits. The lateral surface of the tonsil is covered with a fibrous capsule which is attached to the fibrous plate of the pharynx.

Normally, the tonsil does not extend beyond the fossa and a free space called the **intratonsillar cleft** *(fossa supratonsillaris)* remains over it.

Innervation: the lesser palatine nerve (*nervus palatinus medius* s. *minoris*).

Blood supply: the ascending pharyngeal, ascending palatine, and tonsillar arteries *(arteriae pharyngea ascendens, palatina ascendens, ramus tonsillaris arteriae facialis)*.

THE MUSCLES OF THE PALATE AND FAUCES

1. The **musculus uvulae** (Figs 406, 433) consists of two muscle slips converging towards the midline of the uvula lending it a conical shape. The slips arise from the posterior nasal spine *(spina nasalis posterior)* and from the palatine aponeurosis, run to the midline of the uvula and intertwine to form the raphe.

Action: shortens the uvula by raising it.

Innervation: the pharyngeal plexus *(plexus pharyngeus)*.

Blood supply: the palatine arteries *(arteriae palatinae)*.

2. The **tensor palati muscle** *(musculus tensor veli palatini)* (Fig. 406) is flat, triangular, and lies between the medial pterygoid muscle and the levator palati muscle. It arises by a wide base from the scaphoid fossa *(fossa scaphoidea)* of the sphenoid bone, and the cartilaginous and membranous part and the margin of the bony groove of the pharyngotympanic (auditory) tube to the spine of the sphenoid. It descends and is continuous with a narrow tendon which curves round the pterygoid hamulus and the bursa on it and then spreads out as a wide band of tendinous fibres in the aponeurosis of the soft palate. Some of the bands are inserted into the posterior border of the horizontal part of the palatine bone where they blend partly with the bands of the contralateral muscle.

Action: stretches the anterior part of the soft palate and the pharyngeal part of the pharyngotympanic tube.

Innervation: the nerve to the tensor palati muscle *(nervus tensoris veli palatini)*.

Blood supply: the palatine arteries *(arteriae palatinae)*.

3. The **levator palati muscle** *(musculus levator veli palatini)* (Figs 406, 433) is flat and lies to the back of the tensor palati muscle. It arises from the inferior surface of the petrous part of the temporal bone to the front of the external opening of the carotid canal and from the inferomedial surface of the cartilaginous part of the pharyngotympanic tube.

The bundles stretch downwards, medially and forwards and, expanding, enter the soft palate to blend with the bundles of the contralateral muscle and of other muscles. Some of the bundles are inserted into the middle part of the palatine aponeurosis.

Action: raises the soft palate, narrows the pharyngeal opening of the pharyngotympanic tube.

4. The **palatoglossus muscle** *(musculus palatoglossus)* (Fig. 406) is narrow and flat and is lodged in the palatoglossal arch. It takes origin from the lateral border of the root of the tongue to be as if a continuation of the transverse muscle bundles of the tongue, ascends, and terminates in the aponeurosis of the soft palate.

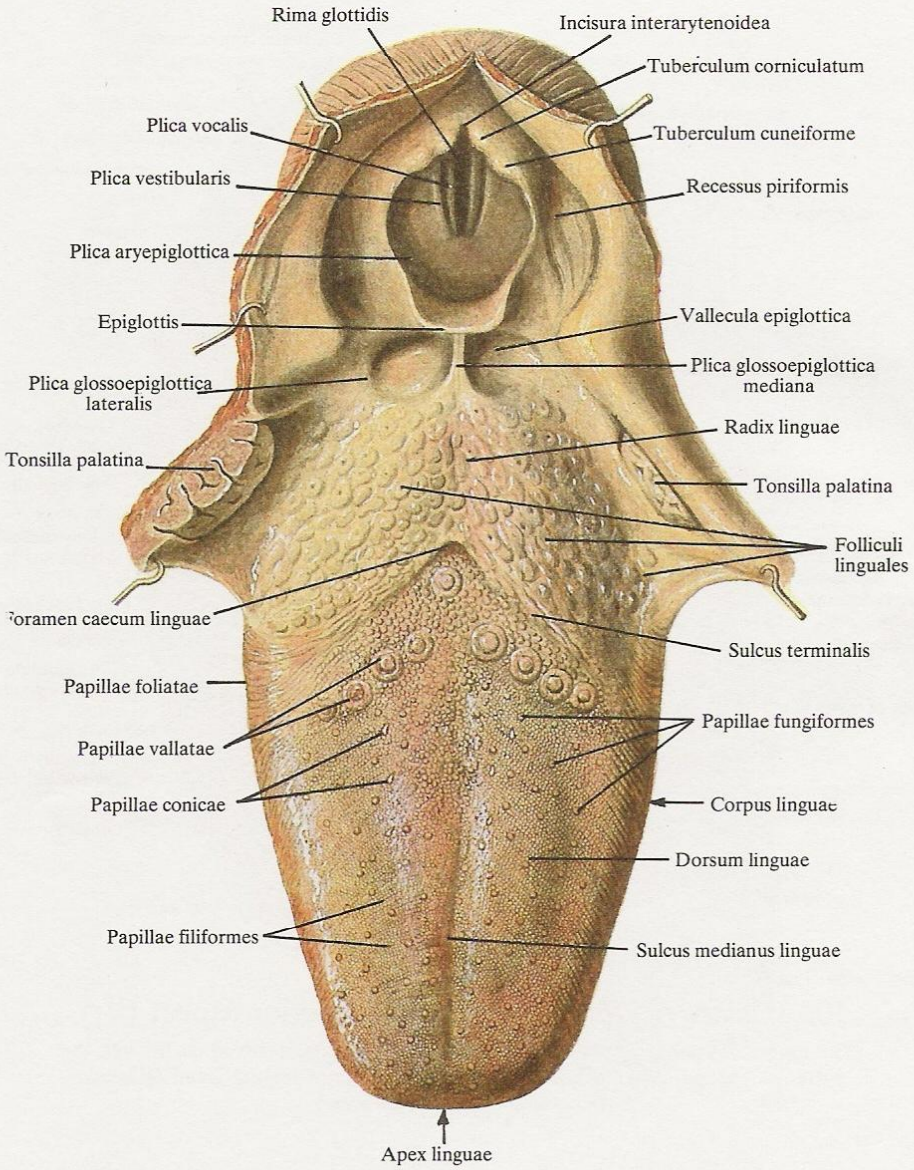
Action: narrows the fauces by bringing the palatoglossal arches closer to the root of the tongue.

5. The **palatopharyngeus muscle** *(musculus palatopharyngeus)* (Figs 406, 433) is flat and triangular and lies for the most part in the palatopharyngeal arch. It arises by its wide base from the posterior wall of the lower part of the pharynx and from the lamina of the thyroid cartilage. The muscle bundles stretch to the midline and upwards and enter the sides of the soft palate and blend with its aponeurosis. Some of the bundles are inserted into the pterygoid hamulus, others are inserted into the inferior border of the medial plate of the cartilaginous part of the pharyngotympanic tube to form the **salpingopharyngeus muscle** *(musculus salpingopharyngeus)*.

Action: brings the palatopharyngeal arches close to one another and pulls the lower part of the pharynx and the larynx upwards.

Innervation: all three (3, 4, 5) muscles are innervated by the pharyngeal plexus *(plexus pharyngeus)*

Blood supply: all three muscles are supplied by the palatine arteries *(arteriae palatinae)*.



407. *Tongue (lingua);* superior aspect ($^1/_1$).

[Mucous membrane of dorsum of tongue *(tunica mucosa dorsi linguae)*.]

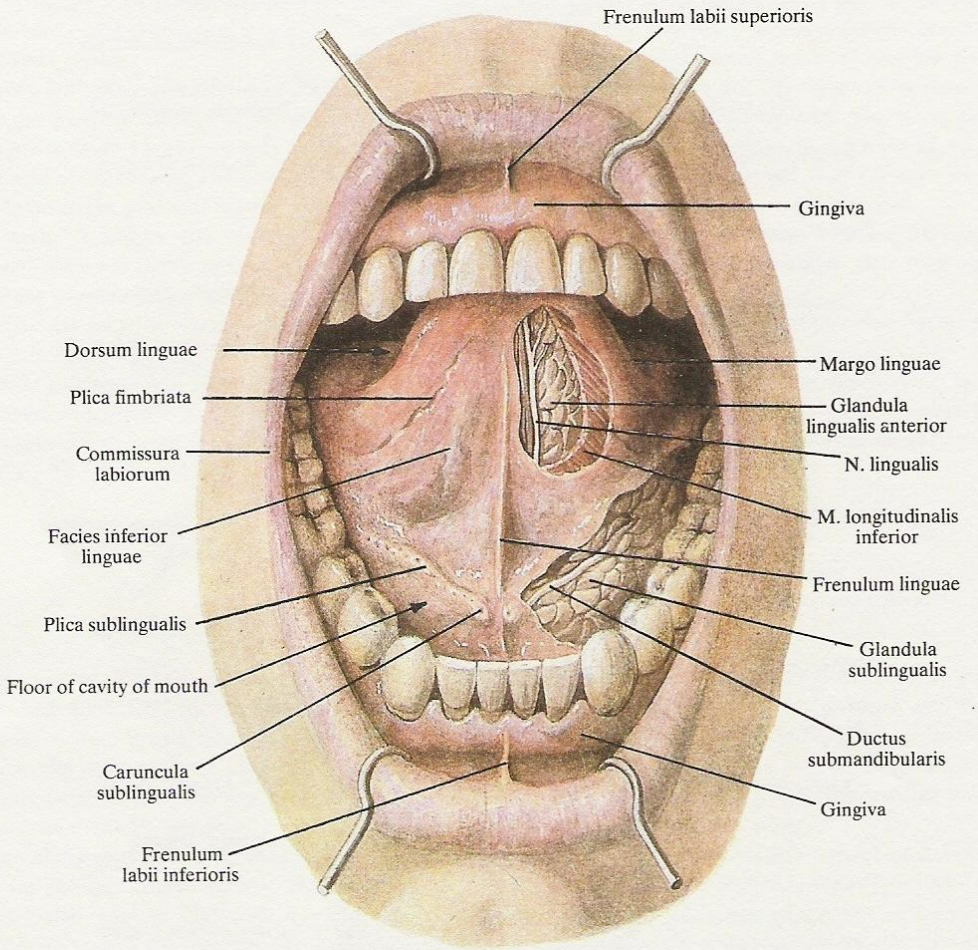
THE TONGUE

The **tongue** (*lingua* s. *glossa*) (Figs 403, 406–413) is a muscular organ covered with mucous membrane on the superior surface, sides, and partly on the inferior surface.

Two parts are distinguished in the tongue: an anterior, free part, or the body of the tongue *(corpus linguae)*, and a posterior part, or the root of the tongue *(radix linguae)*.

The **body of the tongue** *(corpus linguae)* terminates in front by a flat rounded **tip of the tongue** *(apex linguae)*; posteriorly the body is separated from the root by the **sulcus terminalis**.

The sulcus terminalis consists of two parts which meet on the midline of the tongue at an obtuse angle opened to the front. At the apex of this angle is the **foramen caecum of the tongue** *(for-*



408. *Cavity of mouth (cavum oris);* anterior aspect ($^1/_1$).

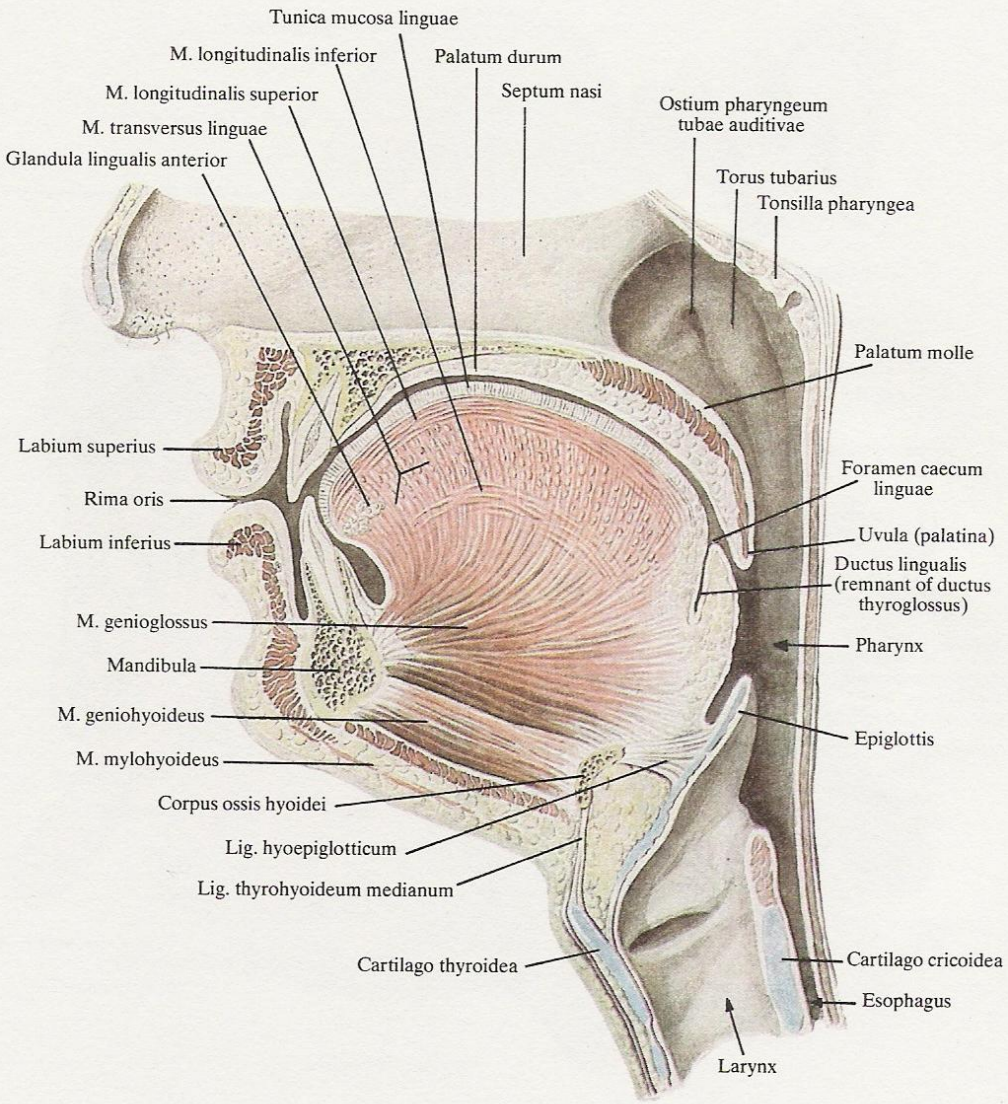
[The tongue is raised; areas of the mucous membrane are removed on the left; the sublingual gland *(glandula sublingualis)* and the anterior lingual gland *(glandula lingualis anterior)* can be seen.]

amen cecum linguae) marking the closed thyroglossal duct *(ductus thyroglossus)*.

The superior, dorsal surface is called the **dorsum of the tongue** *(dorsum linguae)* and is convex longitudinally and transversely. A longitudinal **median sulcus of the tongue** *(sulcus medianus linguae)* divides the body of the tongue into a right and a left part. Corresponding to this sulcus there is a connective-tissue plate, the **septum of the tongue** *(septum linguae)*, within the tongue. The body of the tongue is bounded on each side by the **margin of the tongue** *(margo linguae)*.

The **inferior surface of the tongue** *(facies inferior linguae)* is free only in the anterior part. Its mucous membrane is smooth and has two **fimbriated folds** *(plicae fimbriatae)* which converge anteriorly. A fold of the mucous membrane passes sagittally from the inferior surface of the tongue to the gums; this is the **frenulum of the tongue** *(frenulum linguae)* (Fig. 408). On either side of it, on the floor of the cavity of the mouth, is a small round elevation called the **sublingual papilla** *(caruncula sublingualis)* (Fig. 408) in which the ducts of the salivary submandibular and sublingual glands open: the submandibular duct *(ductus submandibularis)* and the principal sublingual duct *(ductus sublingualis major)*.

Posteriorly and laterally of the sublingual papilla the mucous membrane covers the sublingual gland and forms a longitudinal **sublingual fold** *(plica sublingualis)* (Fig. 408); the smaller sublingual ducts *(ductus sublinguales minores)* open on this fold.



409. *Vestibule of mouth (vestibulum oris) and cavity of mouth (cavum oris)* ($^3/_4$).

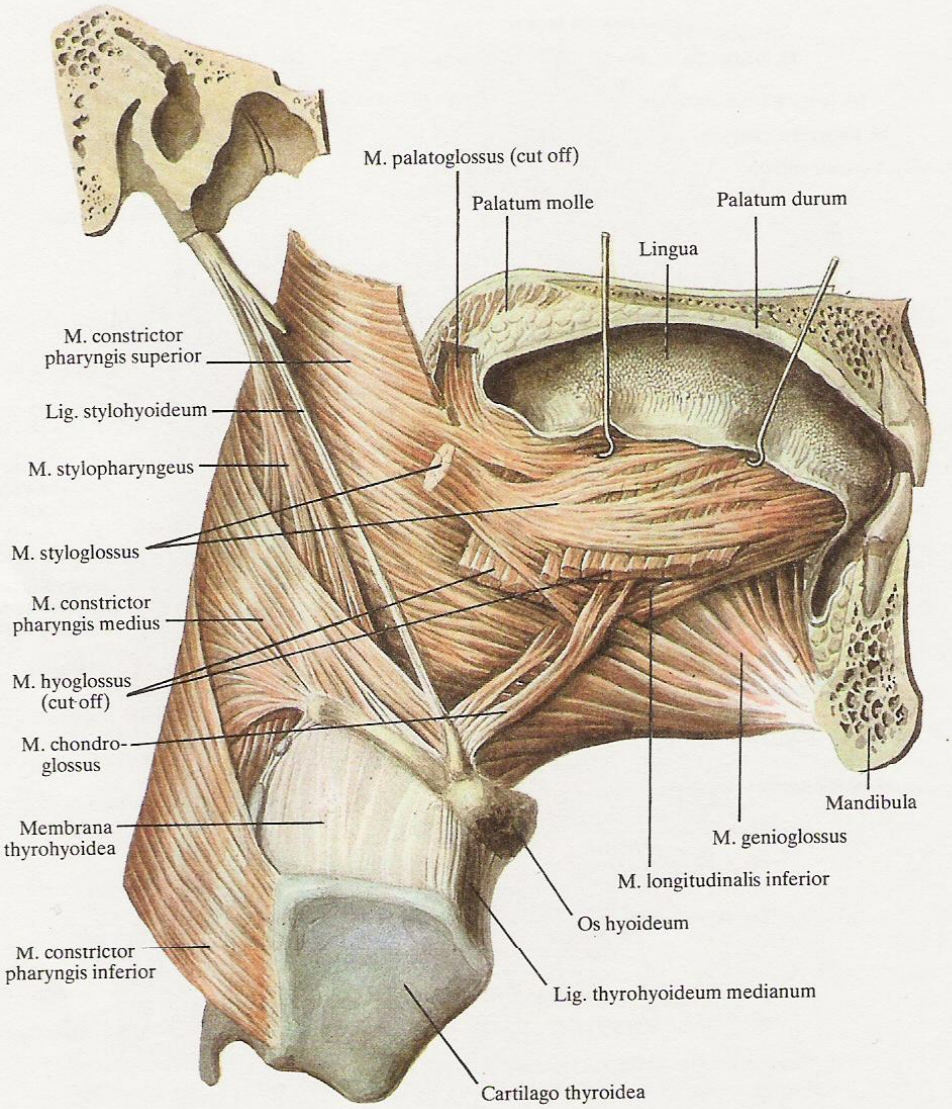
(Sagittal section to the left of the septum of the nose.)

THE MUSCLES OF THE TONGUE

The **muscles of the tongue** *(musculi linguae)* comprise two groups: the muscles that arise from the bones and then interlace in the body of the tongue (skeletal, extrinsic muscles), and the muscles proper of the tongue (intrinsic muscles).

THE SKELETAL (EXTRINSIC) MUSCLES OF THE TONGUE

1. The **styloglossus muscle** *(musculus styloglossus)* (Figs 410, 411, 431) arises from the styloid process and the stylohyoid ligament, passes obliquely downwards, anteriorly, and medially between the stylohyoid muscle and the pharynx, and adjoins the lateral surface of the root of the tongue and the lateral surface of the hyoglossus muscle. Its thicker upper bundle runs along the lateral



410. *Muscles of tongue (musculi linguae), right side;* lateral aspect ($^1/_1$).

margin of the tongue to its tip; the thinner lower bundle penetrates the hyoglossus muscle and passes downwards at the posterior part of the tongue to interlace with the tendinous bands of the contralateral muscle.

Action: pulls the tongue, its root in particular, upwards and backwards.

2. The **hyoglossus muscle** *(musculus hyoglossus)* (Figs 411, 431) is flat and quadrangular and is situated laterally of the genioglossus muscle. It arises from the superior border of the body and the greater horn of the hyoid bone. Its fibres pass upwards and anteriorly towards the lateral margins of the root and body of the tongue where they run between the styloglossus and inferior longitudinal muscles and reach the tip of the tongue.

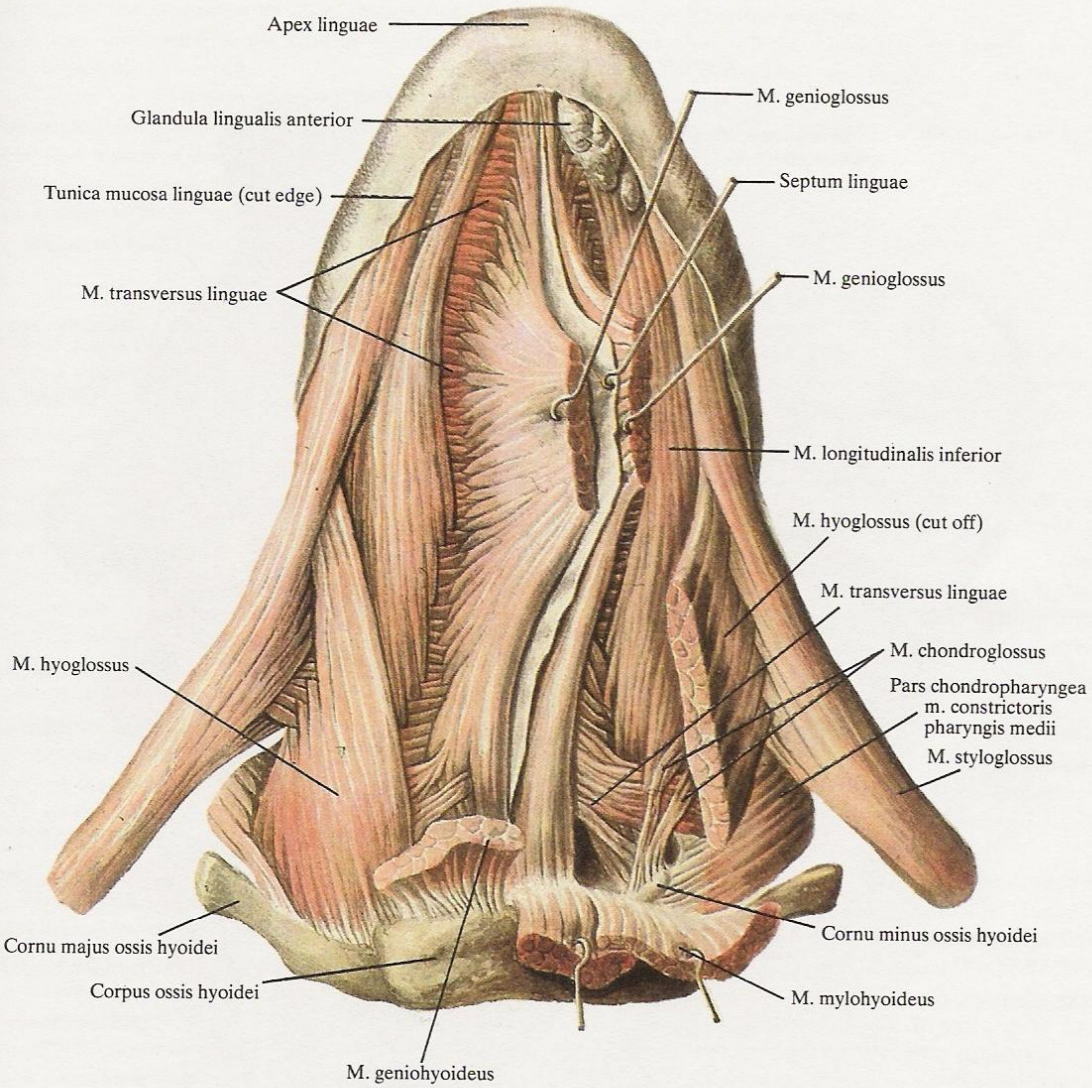
Action: pulls the tongue backwards and downwards.

3. The **genioglossus muscle** *(musculus genioglossus)* (Figs 409–411) lies to both sides of the septum of the tongue. On arising from the spina mentalis (genial tubercle) of the mandible its fibres radiate towards the mucous membrane of the tongue. The lower fibres passing above the geniohyoid muscle are inserted into the body of the hyoid bone and the epiglottis.

Action: pulls the tongue forwards and downwards.

4. The **chondroglossus muscle** *(musculus chondroglossus)* arises by a small muscular slip from the lesser horn of the hyoid bone and is interlaced into the dorsum of the tongue.

Action: pulls the tongue backwards and downwards.



411. *Muscles of tongue;* inferior aspect ($^1/_1$).

THE INTRINSIC MUSCLES OF THE TONGUE

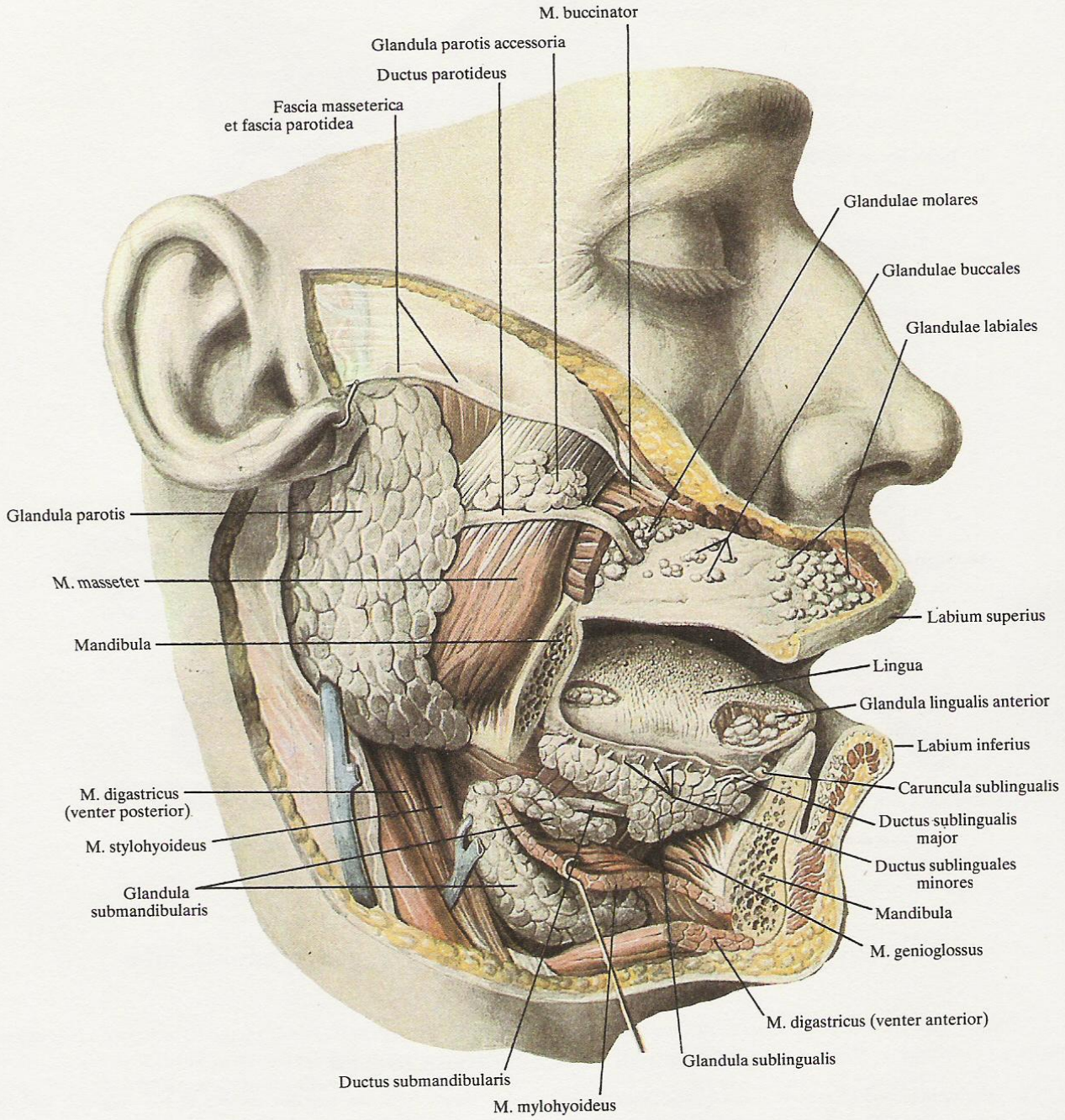
1. The **inferior longitudinal muscle of the tongue** *(musculus longitudinalis inferior)* (Figs 409, 411) is long and narrow and lies in the tongue lateral of the genioglossus muscle. It arises from the mucous membrane of the root of the tongue and passes directly to the front to the tip of the tongue on whose inferior surface it terminates. It lies first between the hyoglossus and genioglossus muscles and then between the styloglossus and genioglossus muscles.

Action: shortens the tongue.

2. The **superior longitudinal muscle of the tongue** *(musculus longitudinalis superior)* (Fig. 409) arises by three slips: the medial slip takes origin from the anterior surface of the epiglottis and the glosso-epiglottic fold *(plica glossoepiglottica mediana)*; the two lateral slips arise from the lesser horns of the hyoid bone. The three slips converge and pass immediately under the mucous membrane along the whole dorsum of the tongue to its tip, interlacing with one another.

Action: bends the tongue, shortening it and raising its tip.

3. The **transverse muscle of the tongue** *(musculus transversus linguae)* (Figs 406, 411) lies along the whole length of the tongue. It consists of separate transversely directed muscle fibres arising



412. *Glands of vestibule and cavity of mouth; right side;* lateral aspect ($^3/_4$).

from the septum of the tongue on its whole distance and partly penetrating it and terminating in the mucous membrane of the margins and dorsum of the tongue.

Action: reduces the transverse diameter of the tongue and makes it transversely convex.

4. The **vertical muscle of the tongue** *(musculus verticalis linguae)*. Its short muscle fibres lie in the free part of the tongue between its dorsum and inferior surface.

Action: flattens the tongue.

Innervation: all the muscles of the tongue are innervated by the terminal branches of the hypoglossal nerve *(rami linguales nervi hypoglossi)*.

Blood supply: all the muscles of the tongue are supplied by the lingual artery *(arteria lingualis)*.

THE MUCOUS MEMBRANE OF THE TONGUE

The **mucous membrane of the tongue** *(tunica mucosa linguae)* (Figs 407, 408) is smooth in the region of the root, inferior surface of the body and the tip, and rough on the dorsum of the tongue. The roughness is produced by the large number of small elevations called the lingual papillae *(papillae linguales)* (Fig. 407) which are divided into four groups.

1. The **filiform papillae** *(papillae filiformes)* occur on the whole body of the tongue and lend its mucous membrane a velvety appearance. These are structures composed of a conical body on whose apex are brush-shaped appendages of epithelium (Fig. 413 A). The filiform papillae are most pronounced in the middle of the dorsum of the tongue and in the vicinity of the vallate papillae *(papillae vallatae)*.

2. The **fungiform papillae** *(papillae fungiformes)*, 150 to 200 in number, are scattered mainly on the dorsum of the tongue nearer to its margins but are rarer in its median parts. They are cone-like projections larger than the filiform papillae and are therefore well detectable among them. On the margins of the tongue they are very flattened.

3. The **vallate papillae** *(papillae vallatae)* are the largest but are hardly elevated above the surface. There are from 7 to 11 of them arranged at the junction of the body with the root, to the front of and parallel to the sulcus terminalis. The central papilla is surrounded by a ridge and is immediately in front of the foramen caecum. Each papilla is composed of a small cylindrical elevation surrounded by a circular groove around which is a ridge of the mucous membrane.

4. The **folia linguae** *(papillae foliatae)* are arranged on the lateral parts (margins) of the tongue. They consist of 5 to 8 folds which are separated by grooves; the folds run almost vertically in front of the palatoglossal arch. The folia linguae differ in size and are pronounced best in the posterior parts of the tongue.

Very many lymphatic **lingual follicles** *(folliculi linguales)* of various size are arranged under the epithelium in the region of the root of the tongue to the epiglottis. The aggregation of these follicles is called the **lingual tonsil** *(tonsilla lingualis)* (Fig. 407).

The **lingual glands** *(glandulae linguales)* (Figs 409, 412, 413 A, 413 B) are grouped into mucous, serous, and mixed glands. The serous glands are in the region of the vallate papillae and the folia linguae. The following glands are distinguished in the mucous and mixed groups.

(a) The **anterior lingual gland** *(glandula lingualis anterior)* is an elongated structure situated on either side of the genioglossus muscle near to and to the back of the tip of the tongue. Its duct opens on the inferior surface of the tongue along the fimbriated fold. Besides, these glands may be arranged in small groups in the posterior part of the margin of the tongue in the styloglossus and palatoglossus muscles. Their ducts open in the folds of the folia linguae.

(b) The **glands of the lingual tonsil** *(glandulae tonsillae lingualis)* form a 4–8-mm thick layer under the mucous membrane. They occupy the region of the lingual tonsil to the epiglottis. Their ducts open in the grooves surrounding the follicles and even in the pit in the middle of the follicle.

Three folds form where the mucous membrane passes over from the root of the tongue to the epiglottis. One of them is unpaired and lies centrally; this is the **glosso-epiglottic fold** *(plica glossoepiglottica mediana)* (Fig. 407). The paired fold stretches to the lateral border of the epiglottis and is called the **pharyngo-epiglottic fold** *(plica glossoepiglottica lateralis)*. Between these folds on each side is a depression called the **vallecula epiglottica**.

In the submucosa of the tongue are embedded a large amount of loose connective tissue and tendinous bands of the intrinsic muscles of the tongue, which form the **aponeurosis of the tongue** *(aponeurosis linguae)* in the aggregate.

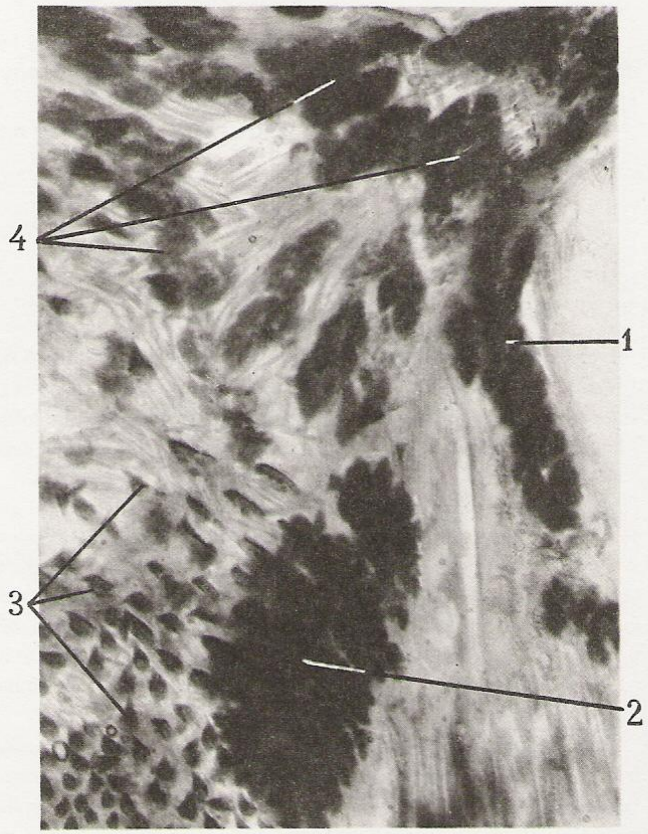
Vessels and nerves pass through the tongue.

Innervation: the anterior two-thirds are innervated by the lingual nerve *(nervus lingualis)* and chorda tympani; the posterior one-third of the tongue is innervated by the glossopharyngeal nerve *(nervus glossopharyngeus)* and the superior laryngeal nerve *(nervus laryngeus superior)*.

Blood supply: the lingual artery *(arteria lingualis)*.

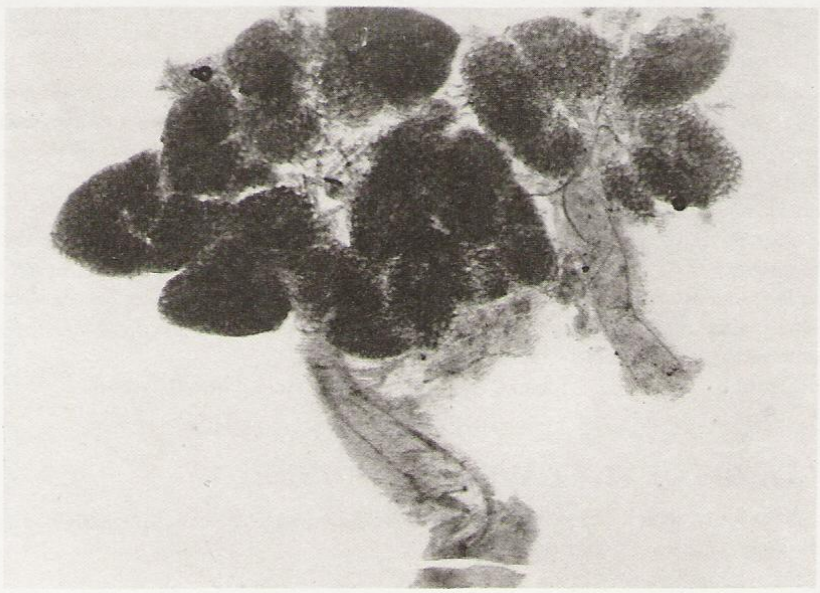
THE SALIVARY GLANDS OF THE CAVITY OF THE MOUTH

The **salivary glands** *(glandulae oris)* secrete saliva, hence their name *(glandulae salivales)*. Three of them are quite large paired organs: (1) the parotid gland *(glandula parotis)*; (2) the submandibular gland *(glandula submandibularis)*; (3) the sublingual gland *(glandula sublingualis)*.



413A. *Glands of tongue* (specimens prepared by Ya. Sinelnikov.) (Photomicrograph.)

(Area of totally stained mucous membrane of the root of the tongue.)
1—glands in the region of the folia linguae
2—glands in the region of the vallate papillae
3—filiform papillae
4—glands in the region of the root of the tongue



413B. *Glands of tongue.* (Photomicrograph.)

(Isolated glands of the region of the root from a totally stained mucous membrane of the tongue.)

THE PAROTID GLAND

The **parotid gland** *(glandula parotis)* (Figs 405, 412) has the shape of an irregular triangle and is situated on the lateral surface of the ramus of the mandible and the posterior border of the masseter muscle *(musculus masseter)*. Inferiorly it may come in contact with the submandibular gland. Its deeply situated part is in relation with the styloid process, the stylohyoid and styloglossus muscles as well as with the internal carotid artery and the internal jugular vein. The gland is enclosed in the **parotid fascia** *(fascia parotidea)* which gives off processes penetrating between the lobules of the gland.

The **parotid duct** *(ductus parotideus)* emerges from the upper part of the anterior border of the gland and runs almost horizontally, parallel to the zygomatic arch, on the lateral surface of the masseter muscle; on reaching the anterior border of the muscle the duct passes through the buccal pad of fat *(corpus adiposum buccae)*, pierces the buccinator muscle, and opens in the vestibule of the mouth at the level of the upper second molar tooth in the parotid papilla *(papilla parotidea)* on the mucous membrane of the cheek. An **accessory parotid gland** *(glandula parotis accessoria)* varying in shape is situated along the length of the parotid duct (Fig. 412). The parotid gland is penetrated by the branches of the external carotid artery, the posterior facial vein, and small branches of the facial nerve.

Innervation: parotid branches of the auriculotemporal nerve *(rami parotidei nervi auriculotemporalis)* *(ganglion oticum)*; nerves attendant to the superficial temporal artery.

Blood supply: parotid branches of the superficial temporal and maxillary arteries (*rami parotidei arteriae temporalis superficialis* et *maxillaris*).

THE SUBMANDIBULAR GLAND

The **submandibular gland** *(glandula submandibularis)* (Figs 412, 414) is situated in the submaxillary triangle *(trigonum submandibulare)* in a fascial sheath formed by the superficial layer of the deep cervical fascia.

The superior surface of the gland comes into relation with the mylohyoid muscle, then the gland curves round the posterior border of the muscle to lie on its anterior surface and touches the posterolateral border of the sublingual gland. Posteriorly the gland reaches the parotid gland and the medial pterygoid muscle. The **submandibular duct** *(ductus submandibularis)* passes on the medial surface of the sublingual gland forward and upward to open on the sublingual papilla *(caruncula sublingualis)* (Fig. 408).

Innervation: the chorda tympani, submandibular ganglion *(ganglion submandibulare)*, and nerves attendant to the facial artery *(arteria facialis)*.

Blood supply: the facial and lingual arteries (*arteriae facialis* et *lingualis*).

THE SUBLINGUAL GLAND

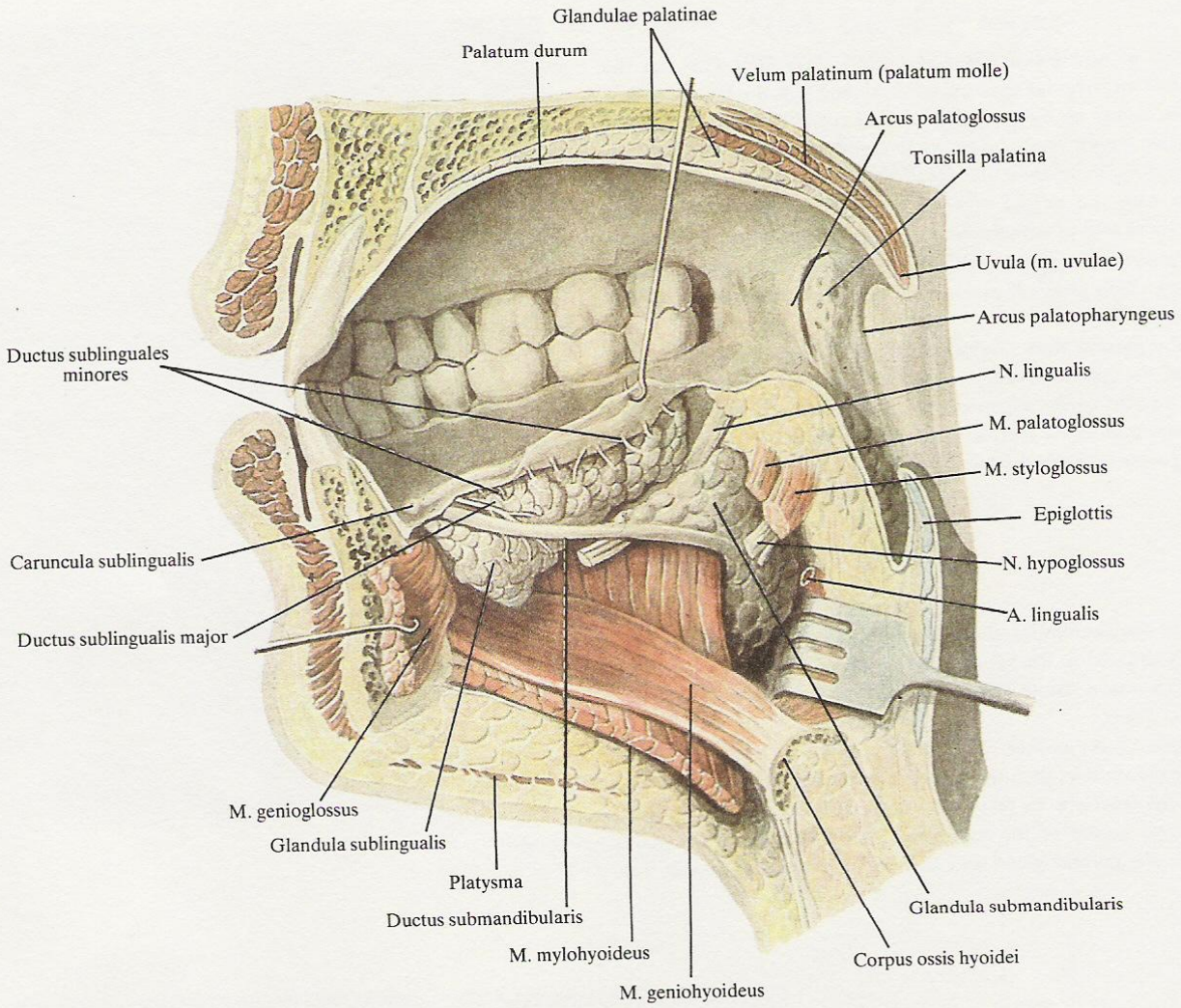
The **sublingual gland** *(glandula sublingualis)* (Figs 408, 412, 414) is situated immediately below the mucous membrane of the floor of the cavity of the mouth on the mylohyoid muscle *(musculus mylohyoideus)* lateral to the geniohyoid muscle *(musculus geniohyoideus)*, the genioglossus muscle *(musculus genioglossus)*, and the hyoglossus muscle *(musculus hyoglossus)*. The anterior end of the gland is in relation with the medial surface of the body of the mandible, the posterior end—with the submandibular gland. Numerous short smaller **sublingual ducts** *(ductus sublinguales minores)* open along the sublingual fold *(plica sublingualis)*. Besides these small ducts, there is sometimes a **principal sublingual duct** *(ductus sublingualis major)*; it stretches on the medial surface of the gland and opens on the sublingual papilla either independently or alongside the submandibular duct.

Innervation: the chorda tympani, submandibular ganglion *(ganglion submandibulare)*, and nerves attendant to the facial artery *(arteria facialis)*.

Blood supply: the sublingual and submental arteries (*arteriae sublingualis* et *submentalis*).

THE TEETH

The teeth *(dentes)* (Fig. 415) are securely set in the sockets *(alveoli dentales)* of the maxilla and mandible. The type of articulation between the tooth and the socket is called a **peg-and-socket suture** *(gomphosis)* which is related to fibrous joints *(junctura fibrosa)*.



414. *Glands of cavity of mouth, right side;* medial aspect ($^4/_5$).

The teeth of a human erupt in two periods. The deciduous, or milk, teeth *(dentes decidui)* erupt in the first period, the permanent teeth *(dentes permanentes)*, in the second period.

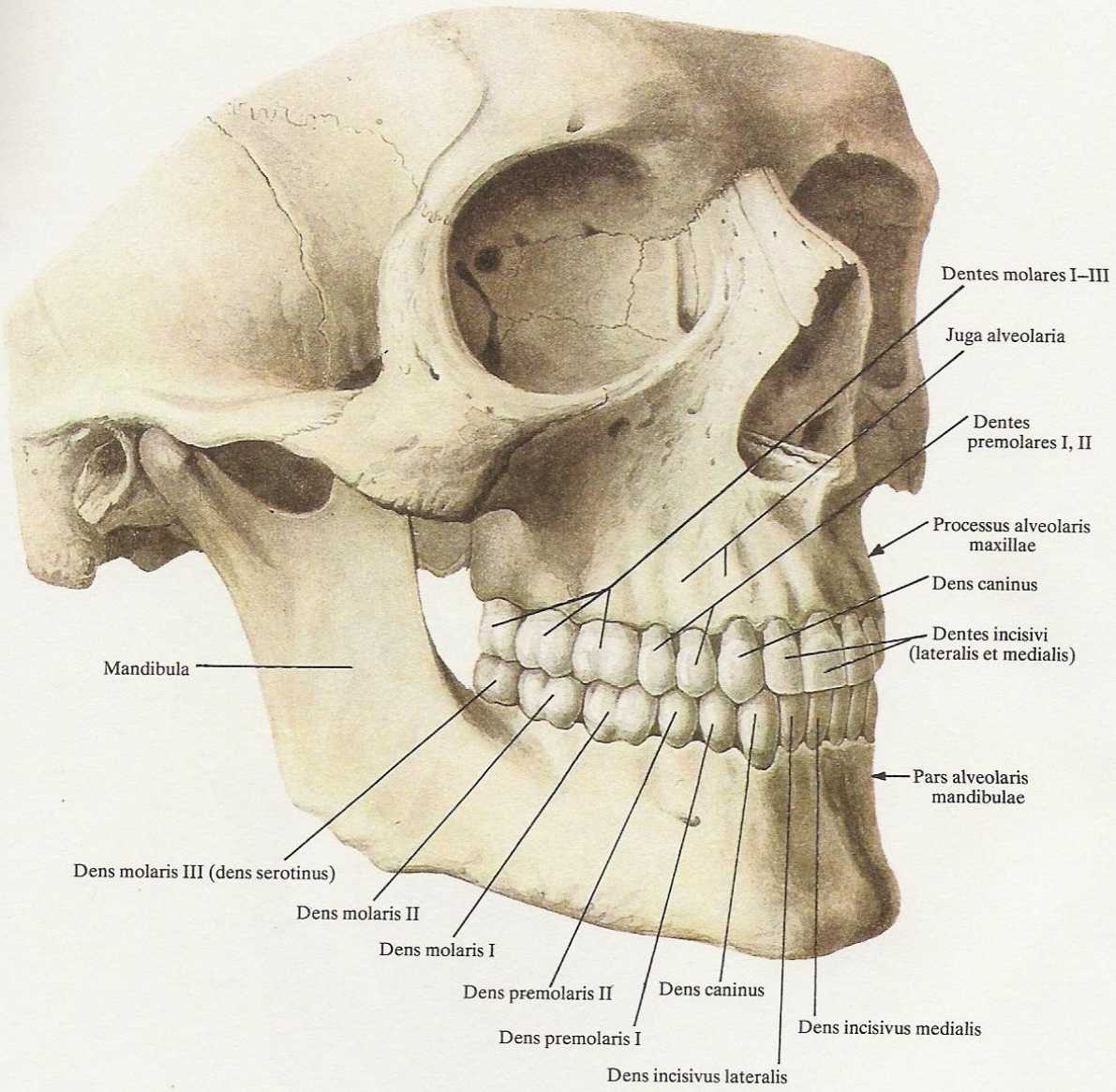
Each tooth has a part projecting from the gum, which is called the **crown of the tooth** *(corona dentis)* (Figs 416, 417), a part embraced by the gum, which is called the **neck of the tooth** (*collum* s. *cervix dentis*), and a part set in the socket of the jaw, which is known as the **root of the tooth** *(radix dentis)*. Some teeth have only one root, others have more.

The bulk of the tooth is composed of **dentine** *(dentinum)*. The dentine of the crown is coated with **enamel** *(enamelum)*, that of the neck and root, with **cement** *(cementum)*.

The root of the tooth is surrounded by the **alveolar periosteum** *(periodontium)* holding the root securely in the socket. Besides, the **gums** *(gingivae)* (the mucous membrane of the cavity of the mouth which covers the alveolar process of the maxilla and the alveolar part of the body of the mandible and is tightly fused with their periosteum as well as with the alveolar periosteum) contribute greatly to the fixation of the teeth.

The crown of the tooth contains the **cavity of the tooth** *(cavum dentis)* which is continuous with a narrow **root canal of the tooth** *(canalis radicis dentis)*. On the **root apex** *(apex radicis dentis)* there is a small **root foramen** *(foramen apicis radicis dentis)* transmitting vessels and nerves into the cavity of the tooth which contains the **pulp of the tooth** *(pulpa dentis)*. The **pulp of the crown** *(pulpa coronale)* and the **pulp of the root** *(pulpa radicularis)* are distinguished.

According to the shape of the crown, the teeth are grouped into **incisor teeth** *(dentes incisivi)*, **canine teeth** *(dentes canini)*, **premo-**



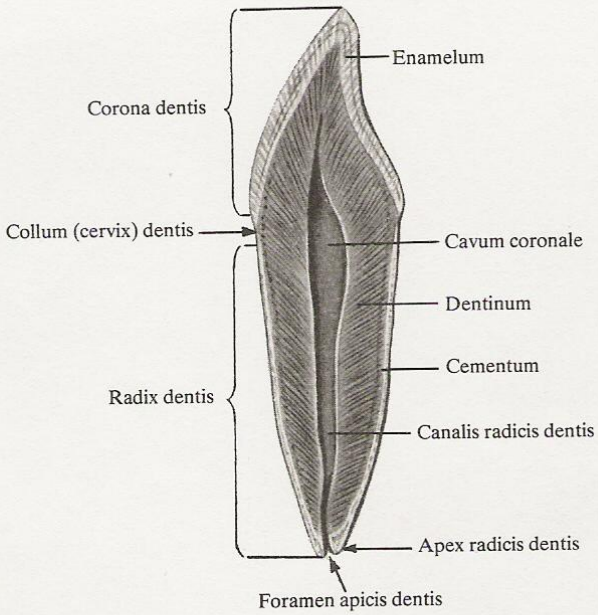
415. *Maxillary and mandibular teeth, permanent (dentes permanentes)* ($^1/_1$).

lar teeth *(dentes premolares)* and **molar teeth** *(dentes molares)*.

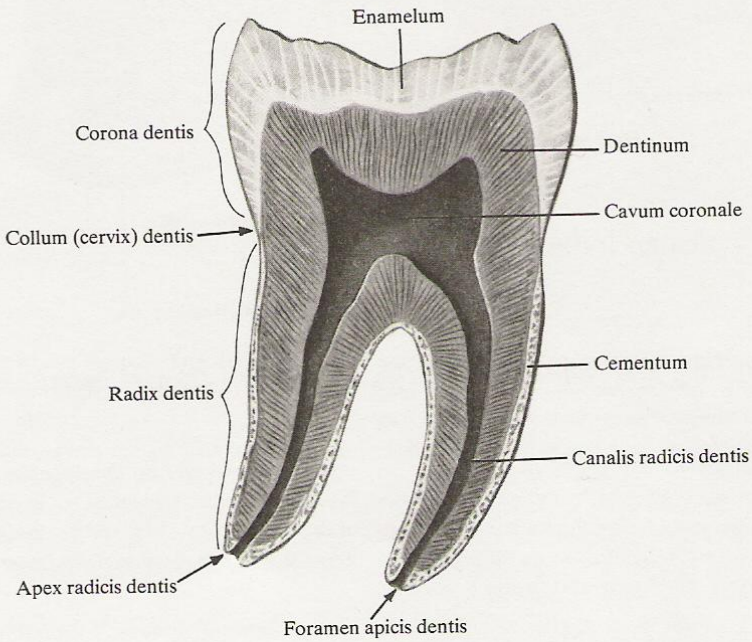
The following surfaces are distinguished in the crown of the tooth: a **lingual surface** *(facies lingualis)* facing the tongue; a **vestibular (facial) surface** (*facies vestibularis* s. *facialis)* facing the vestibule of the mouth; an **occlusal surface** *(facies occlusalis)* facing a similar surface of the tooth on the opposite jaw; and two **contiguous surfaces** *(facies contactus)* which are in contact with the adjacent teeth in the same dental arch, and are known as the **mesial surface** *(facies mesialis)* and the **distal surface** *(facies distalis)*.

THE DECIDUOUS TEETH

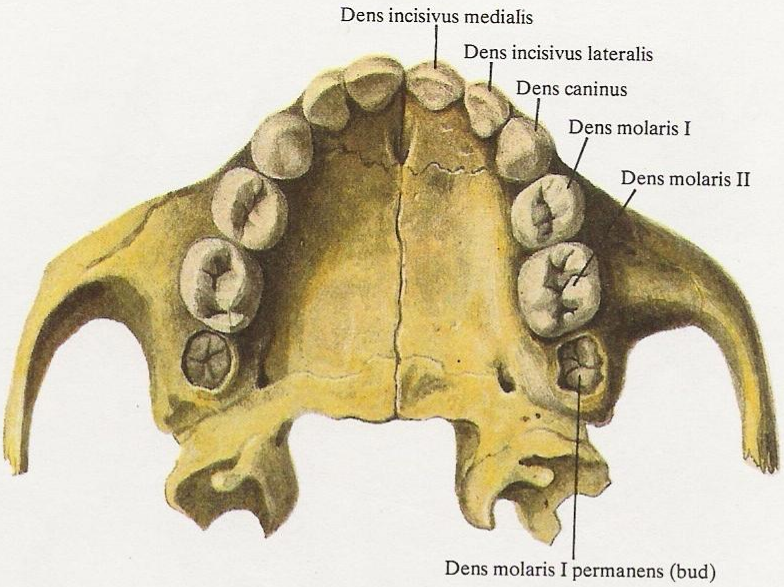
The **deciduous (milk) teeth** *(dentes decidui)* (Figs 418–420), 20 in number (ten on each jaw), erupt between the ages of 6 months and 2 years. They are smaller than the respective permanent teeth; their crowns are relatively wider and shorter while the roots are



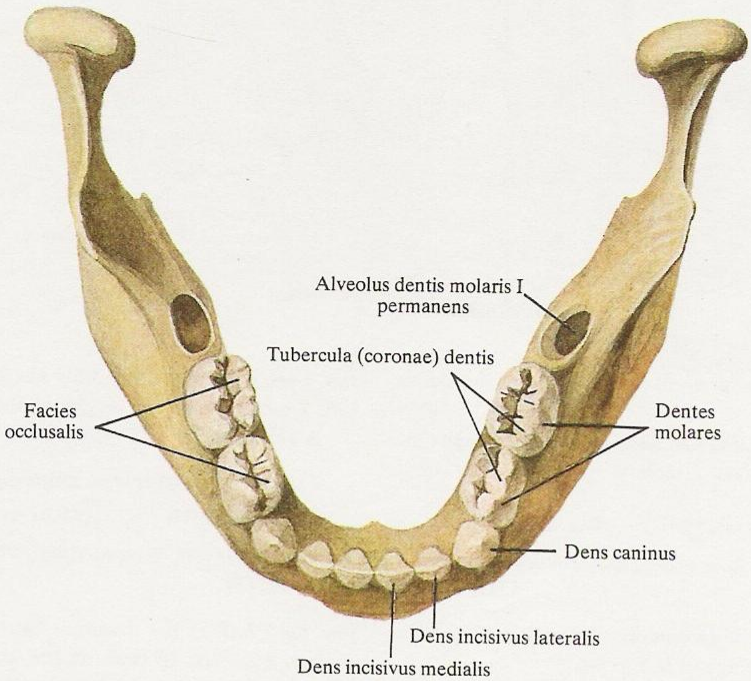
416. *Permanent single-root tooth* (represented semischematically).
(Vertical section.)



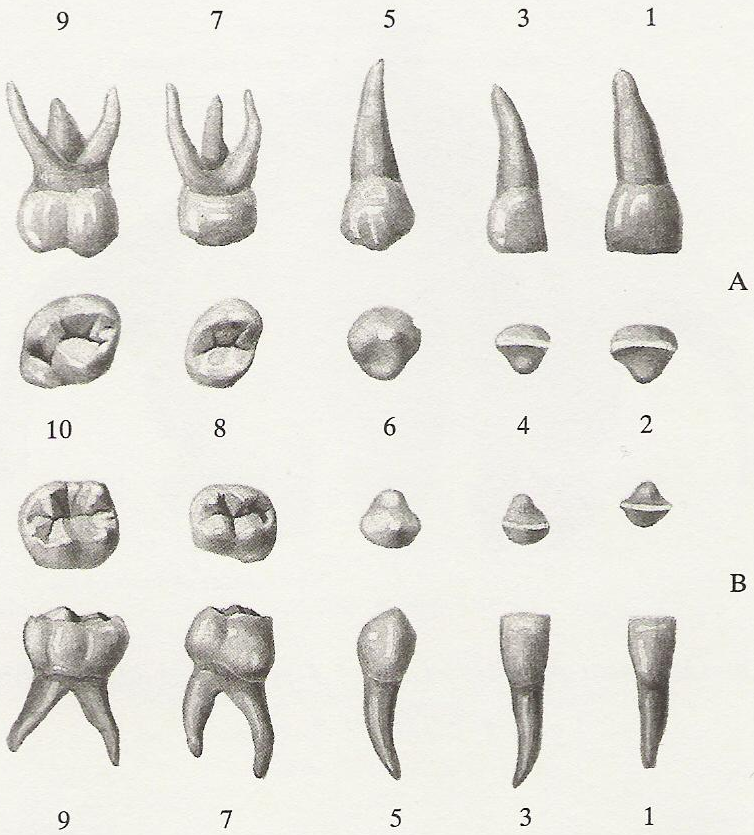
417. *Permanent double-root tooth* (represented semischematically).
(Vertical section.)



418. *Deciduous maxillary teeth of 4-year-old child;* inferior aspect ($^{4}/_{3}$).



419. *Deciduous mandibular teeth of 4-year-old child;* superior aspect ($^{1}/_{1}$).



420. *Deciduous teeth (dentes decidui) of right side.* A—maxillary teeth; B—mandibular teeth

1—medial incisor, vestibular (facial) surface
2—medial incisor, cutting edge
3—lateral incisor, vestibular (facial) surface
4—lateral incisor, cutting edge
5—canine tooth, vestibular (facial) surface
6—canine tooth, cutting edge
7—first molar, vestibular (facial) surface
8—first molar, occlusal surface
9—second molar, vestibular (facial) surface
10—second molar, occlusal surface

rather short. There are no premolars among the deciduous teeth.

The deciduous teeth formula. On each half of the maxilla are 2 incisors, 1 canine, 0 premolars, 2 molars; 10 teeth on the whole jaw. Each half of the mandible has 2 incisors, 1 canine, 0 premolars, 2 molars; 10 teeth on the whole jaw.

A child has 10 + 10 = 20 teeth.

This is indicated by the following formula: $\frac{2012|2102}{2012|2102}$.

THE PERMANENT TEETH

The **permanent teeth** *(dentes permanentes)* (Figs 421-428), 32 in number, start erupting at the age of 6-7 years.

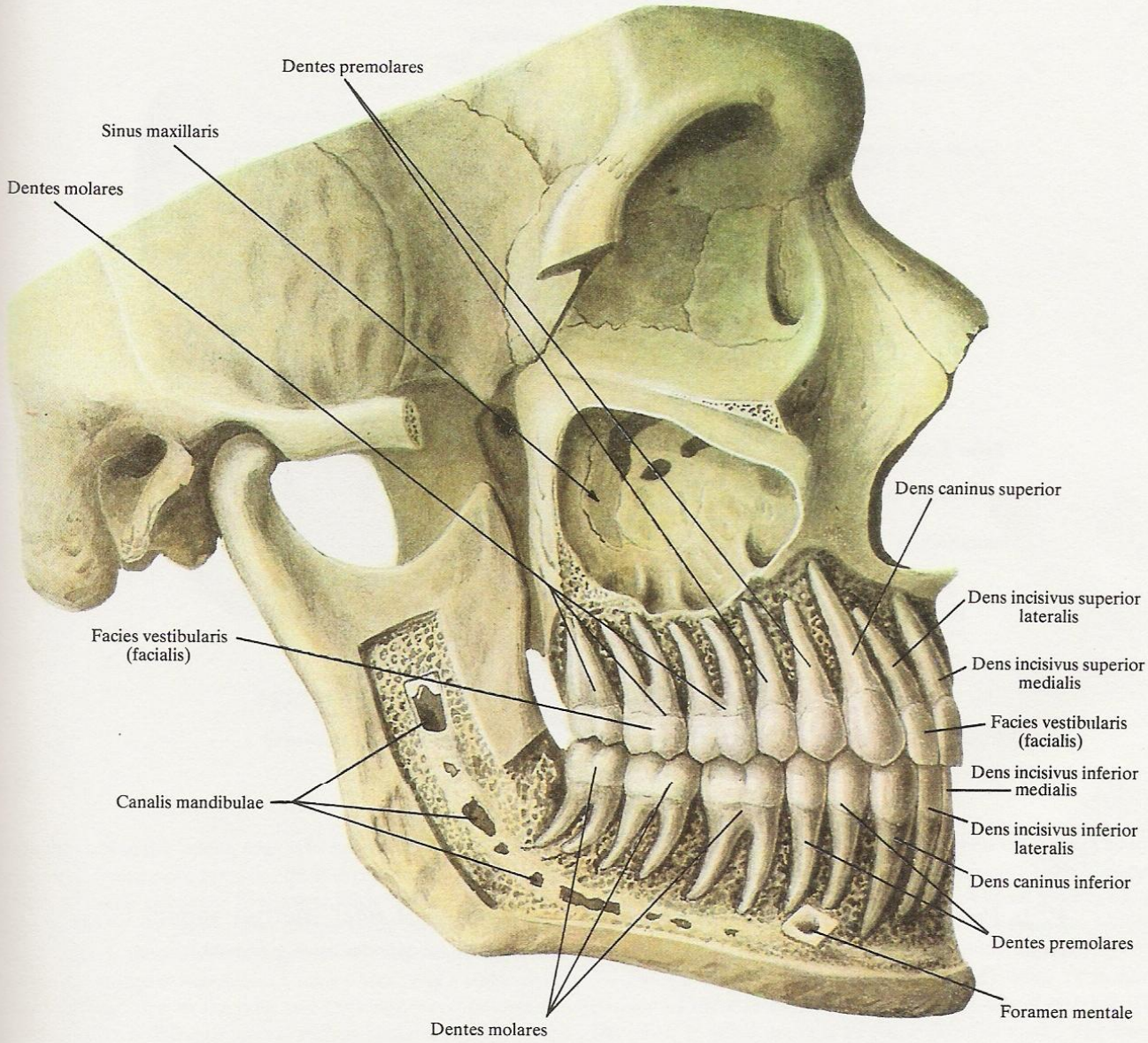
Some of them erupt in addition to the 20 deciduous teeth, others replace the lost deciduous teeth.

The permanent teeth formula. Each half of the maxilla has 2 incisors, 1 canine, 2 premolars, 3 molars; 16 teeth on the whole jaw. Each half of the mandible bears 2 incisors, 1 canine, 2 premolars, 3 molars; 16 teeth on the whole jaw.

A human adult has 16 + 16 = 32 teeth.

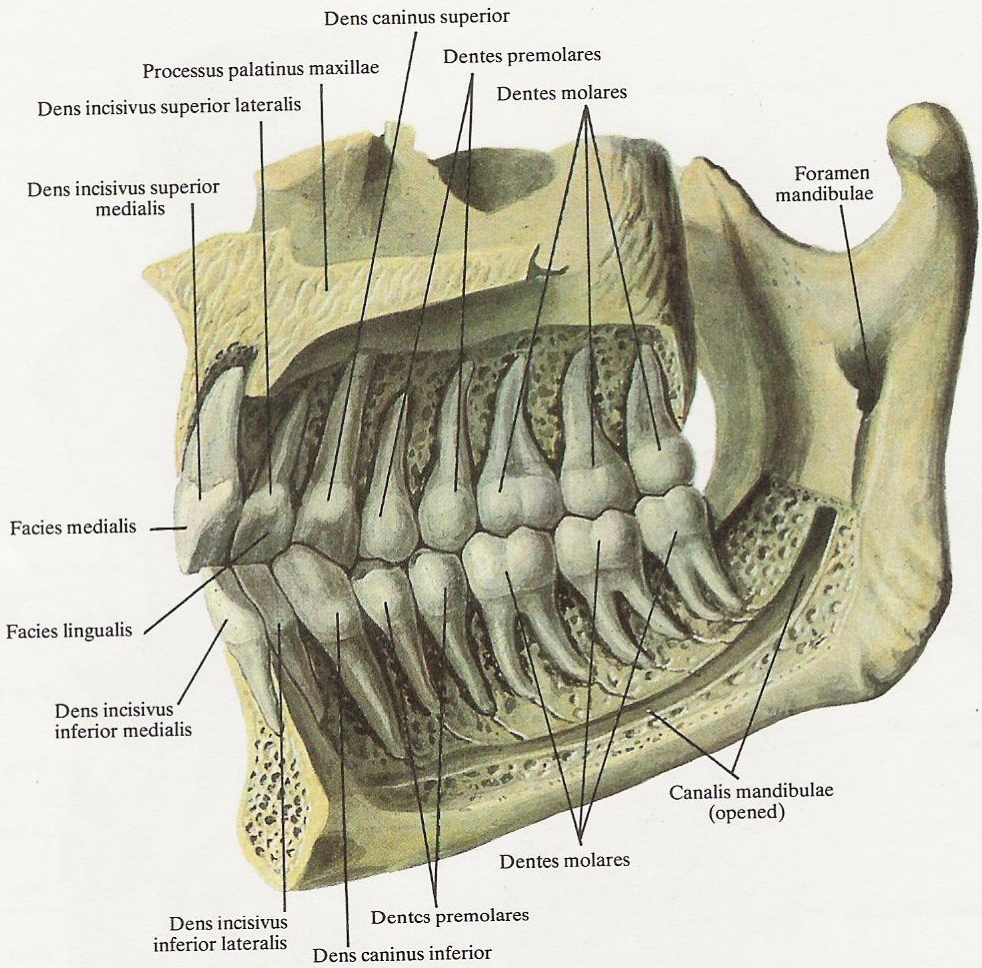
This is indicated by the formula: $\frac{3212|2123}{3212|2123}$.

The **incisor teeth** *(dentes incisivi)* (Figs 421-428), 8 in number,



421. *Permanent maxillary and mandibular teeth of right side;* lateral aspect (1/1).

(The outer table of the bony substance of the alveolar processes is removed; the maxillary sinus and partly the mandibular canal are opened.)



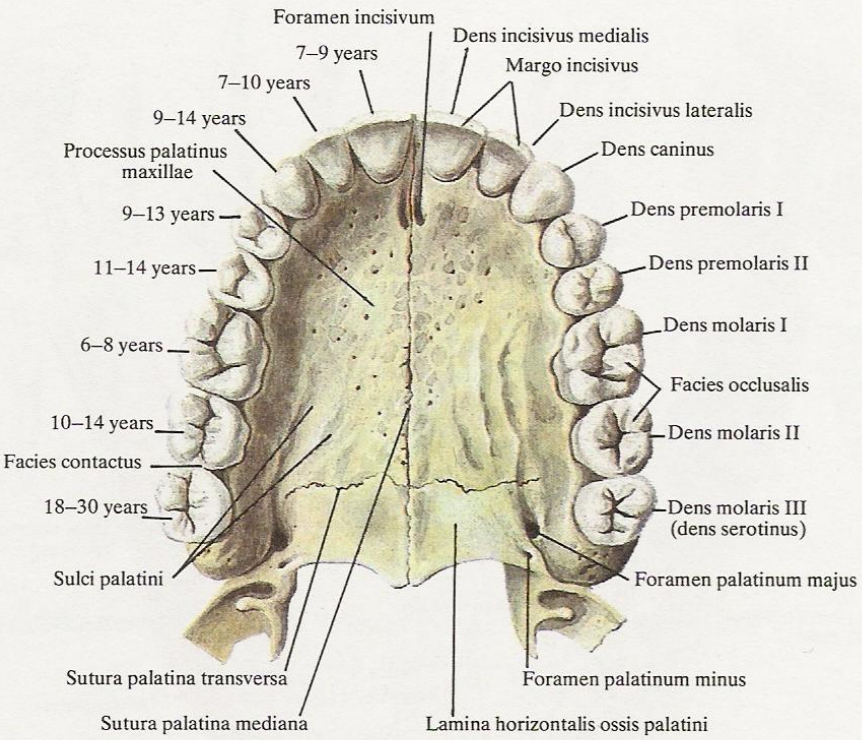
422. *Permanent maxillary and mandibular teeth of right side;* medial aspect ($^1/_1$).
(The inner table of the alveolar processes is removed; the mandibular canal is opened.)

are arranged 4 on each jaw; 2 are medial and the other 2, lateral. The crowns of the teeth are shaped like a chisel with a sharp cutting edge. The vestibular surface of the crown is slightly convex. On the lingual surface, at the neck, is the **tubercle of the tooth** *(tuberculum coronae dentis)*. The contiguous surface is triangular because the crown is narrow at the cutting edge but becomes thicker towards the neck. The upper (maxillary) incisors are larger than the lower (mandibular) ones. The upper medial incisors are the largest. The root is conical and compressed from the sides. Its sides bear poorly pronounced longitudinal grooves.

The following three signs are used to distinguish the teeth of the right side from those of the left side: the root sign, the crown angle sign, and the enamel (crown) curvature sign.

In the incisors these signs are manifested as follows: the root sign—the root is inclined to the side corresponding to its position; the crown angle sign—the distal angle formed by the lateral and cutting edges is rounded; the enamel curvature sign—the vestibular (facial) surface is convex at the mesial edge but becomes flat gradually in the direction of the distal edge. The root sign is clearly pronounced in the upper incisors but is inconstant in the lower ones.

The **canine teeth** *(dentes canini)* (Figs 421-428), 4 in number, are arranged one on each side immediately distal of the incisors on each jaw. They are distinguished by a long root and a conical crown. Like in the incisors, the crown has four surfaces. The vestibular (facial) surface is convex, pentagonal, and is widest be-



423. *Permanent maxillary teeth;* inferior aspect ($^1/_1$).

(The time of tooth eruption is indicated on the left side of the drawing.)

tween the ends of the cutting edge. The lingual surface bears at the neck a well pronounced tubercle which is continuous with a longitudinal elevation passing to the mesial angle of the cutting edge. The tubercle is not pronounced on the lower canine tooth. The cutting edge is formed of two segments meeting at an angle; the contiguous surface is triangular. A canine tooth has a single root, which is compressed on the sides and has longitudinal grooves on the distal surface. The root apex is slightly inclined distally (laterally).

The upper canine teeth are distinguished from the lower canines by a larger size, a wider crown, and a longer root.

The deciduous canine teeth greatly resemble the permanent canines; their roots are curved and directed towards the first molar.

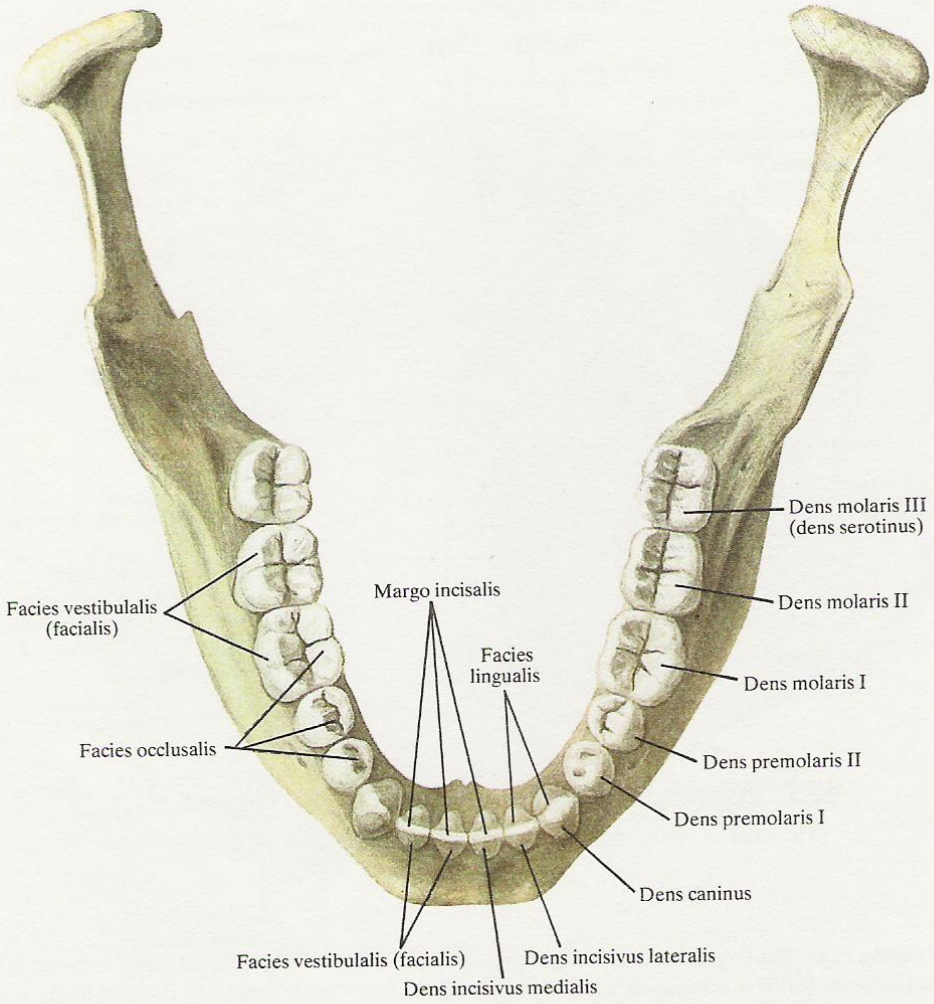
The **premolar teeth** *(dentes premolares)* (Figs 421–428), 8 in number, are set 2 on each side distally to the canine tooth on each jaw. The occlusal surface is almost quadrangular in shape and is divided by a groove into two eminences, or cusps. The buccal cusp is developed stronger than the lingual cusp. These masticating cusps are more massive on the upper teeth and are separated one from the other more distinctly. The premolars usually have a single root, that of the upper first premolars is bifurcate. The root of the lower teeth is conical, the root of the upper teeth is slightly compressed anteroposteriorly and has longitudinal grooves on the anterior and posterior surfaces. The upper first premolar contains two canals in its root, one buccal and the other lingual.

The **molar teeth** *(dentes molares)* (Figs 421–428), 12 in number, are set distal of the premolars, 3 on each side of each jaw. The last molar is called the **dens serotinus** (wisdom tooth). The crown is cubic.

The occlusal surface of the upper molars is divided into four cusps by grooves which form the letter H—two buccal and two lingual cusps. Each upper molar tooth has three roots: one lingual with the apex facing the hard palate, and the other two buccal whose apices are directed to the back. The size of the upper molars diminishes from the first to the third tooth.

The third molar tooth, dens serotinus, is the smallest and varies both in the shape of the crown and the number of roots, which may be more, or less, than three. The cavity of the tooth is large and continues into each cusp. Each root has a separate canal.

The lower molars are larger than the upper molars and two grooves divide their occlusal surface into four cusps. Two cusps



424. *Permanent mandibular teeth;* superior aspect ($^1/_1$).

are at the buccal edge and two, at the lingual edge. Only the first molar has five cusps, three of which are at the buccal edge. The lower third molar, just like the upper third molar, is extremely variable.

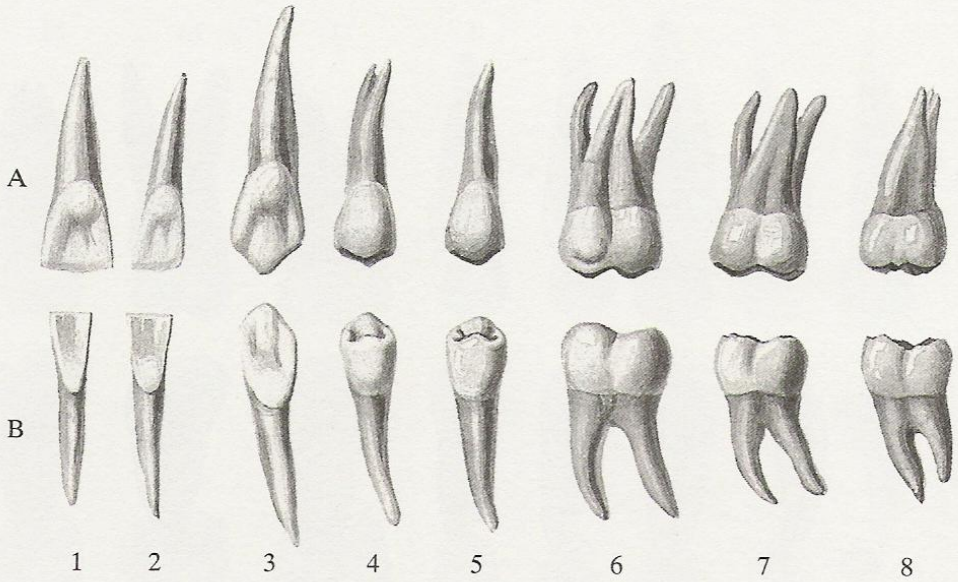
Each lower molar has two roots, anterior and posterior, which are compressed anteroposteriorly. The anterior root is almost vertical while the posterior root is directed to the back. The cavity of the tooth follows the outlines of the crown and continues into each cusp. Two canals are present in the anterior root and one canal in the posterior root.

The size of the lower molars, like that of the upper molars, reduces from the first to the third tooth.

The deciduous molars, 8 in number, are shaped like the permanent molars.

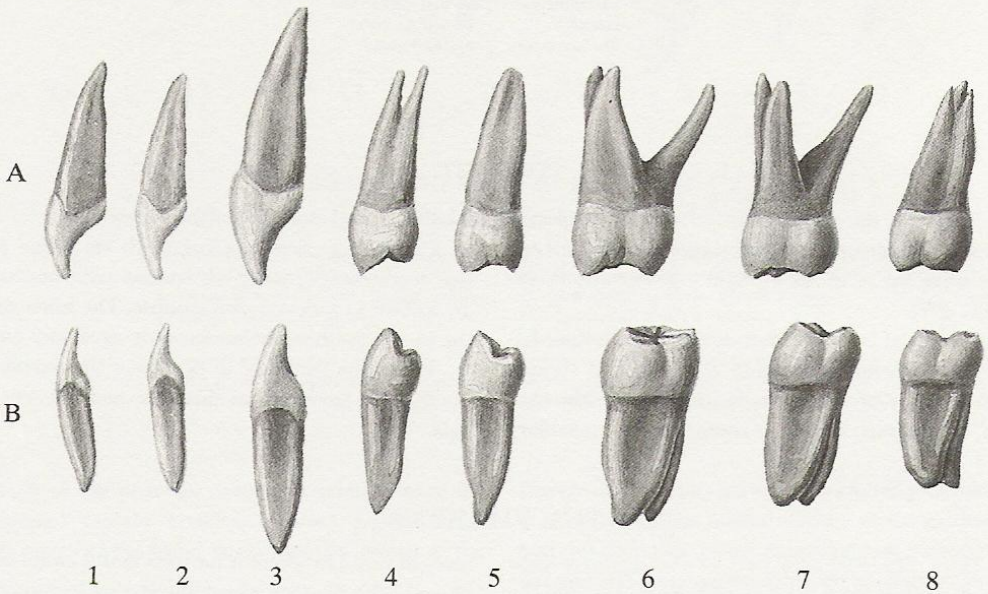
Innervation: the maxillary teeth are innervated by the superior dental nerves *(nervi alveolares superiores)*, anterior, middle, and posterior superior dental nerves (*rami alveolares superiores anteriores, medius* et *posteriores*) from the superior dental plexus; the mandibular teeth are innervated by the inferior dental nerves *(rami dentales inferiores nervus alveolaris inferior)*.

Blood supply: the maxillary teeth are supplied by the dental branches of the anterior and posterior superior dental arteries (*rami dentales arteriae alveolaris superioris anterioris* et *posterioris*); the mandibular teeth are supplied by the dental branches of the inferior dental artery *(rami dentales arteriae alveolaris inferioris)*.



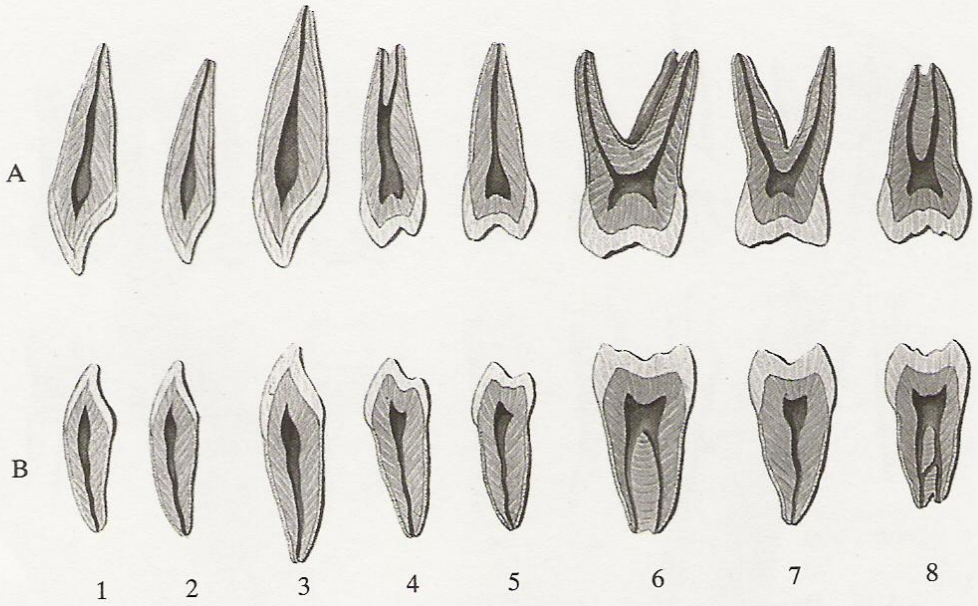
425. *Permanent teeth (dentes permanentes) of right side* ($^1/_1$).
A—maxillary teeth, lingual surface
B—mandibular teeth, lingual surface.

1—medial incisor
2—lateral incisor
3—canine
4—first premolar
5—second premolar
6—first molar
7—second molar
8—third molar



426. *Permanent teeth of right side* ($^1/_1$).
A—maxillary teeth; B—mandibular teeth

1—medial incisor, mesial surface
2—lateral incisor, mesial surface
3—canine, mesial surface
4—first premolar, mesial surface
5—second premolar, mesial surface
6—first molar, mesial surface
7—second molar, mesial surface
8—third molar, mesial surface



427. *Permanent teeth of right side* ($^1/_1$).
A—maxillary teeth; B—mandibular teeth

(Section of each tooth is made in the direction from the vestibule of the mouth to the tongue.)

1—medial incisor
2—lateral incisor
3—canine
4—first premolar
5—second premolar
6—first molar
7—second molar
8—third molar

THE BITE

The term bite indicates the relationship between the **superior dental arch** *(arcus dentalis superior)* and the **inferior dental arch** *(arcus dentalis inferior)* when the teeth are brought together into occlusion (Figs 415, 421, 422).

In occlusion the teeth of one jaw come in contact with their fellows of the other jaw; each maxillary tooth also comes in contact with the tooth set laterally of the fellow mandibular tooth; each mandibular tooth, in contrast, comes in contact with a maxillary tooth standing medially of the fellow tooth.

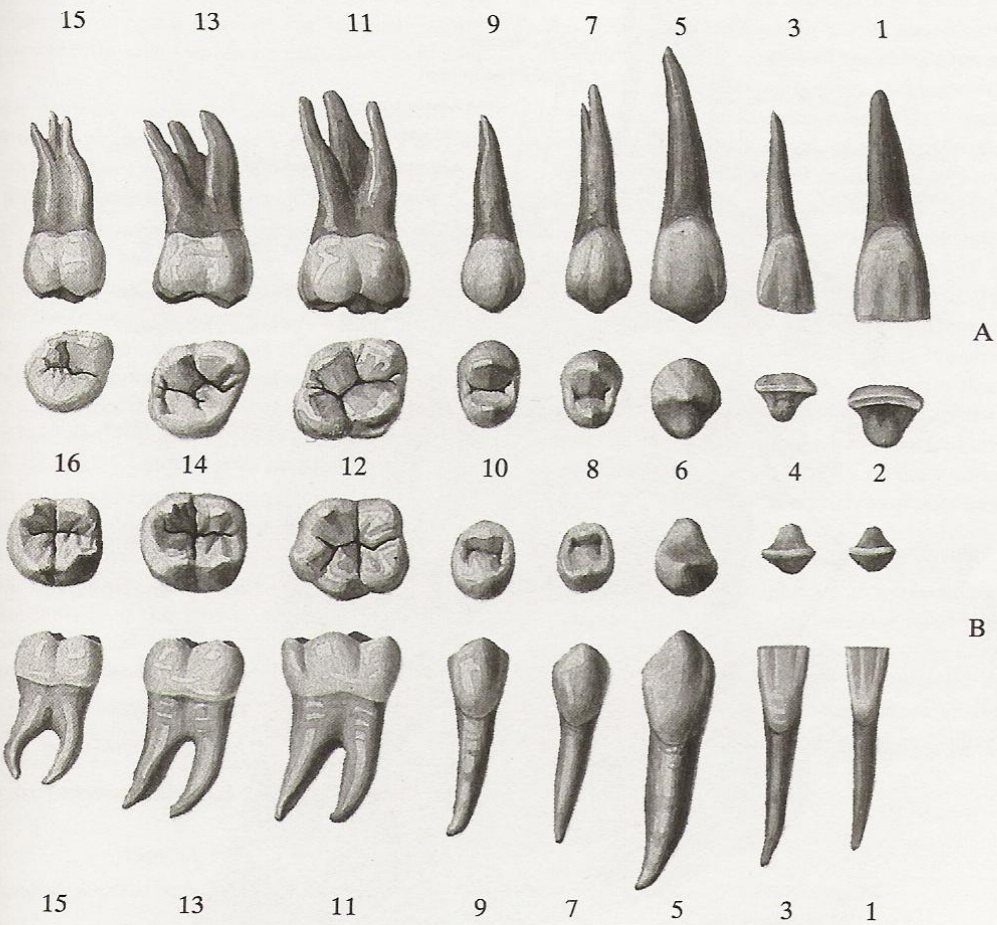
Contacting corresponding teeth are called principal antagonists, teeth coming partly in contact with noncorresponding teeth are known as accessory antagonists. The lower medial incisors and the maxillary third molars have no accessory antagonists.

When the teeth are in occlusion the maxillary incisors partly overlap the mandibular incisors and jut out over them as a rule.

THE PHARYNX

The **pharynx** (Figs 429–435) is a part of the digestive tube along which the bolus moves from the cavity of the mouth into the oesophagus. At the same time the pharynx is the pathway for air from the cavity of the mouth into the larynx and in the opposite direction.

The pharynx is situated in front of the cervical segment of the vertebral column, its posterior wall adjoining the prevertebral fascia, and stretches from the base of the skull to the level of the sixth cervical vertebra where it narrows and is continuous with the oesophagus. The pharynx communicates widely with the cavities of the nose, mouth, and larynx which are in front of it. The pharynx is 12–15 cm long. Its upper wall, called the **pharyngeal fornix** *(fornix pharyngis)*, is attached to the external surface of the base of the skull from the pharyngeal tubercle and then, lateral of it for the distance to the carotid canals, and then anteriorly to the base of the medial pterygoid plate.



428. *Permanent teeth of right side* ($^1/_1$).
A—maxillary teeth; B—mandibular teeth

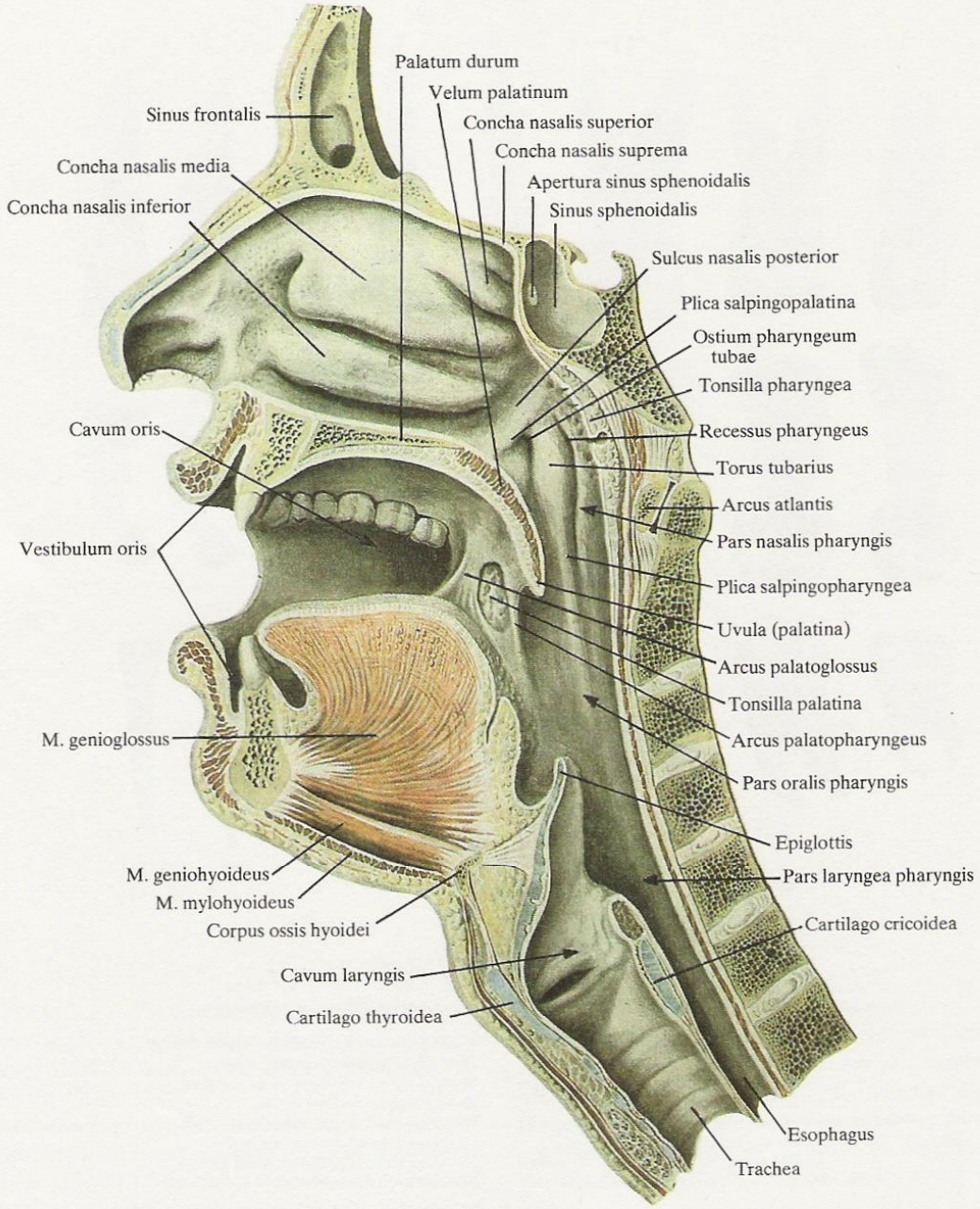
1—medial incisor, vestibular (facial) surface
2—medial incisor, cutting edge
3—lateral incisor, vestibular (facial) surface
4—lateral incisor, cutting edge
5—canine, vestibular (facial) surface
6—canine, cutting edge
7—first premolar, vestibular (facial) surface
8—first premolar, occlusal surface
9—second premolar, vestibular (facial) surface
10—second premolar, occlusal surface
11—first molar, vestibular (facial) surface
12—first molar, occlusal surface
13—second molar, vestibular (facial) surface
14—second molar, occlusal surface
15—third molar, vestibular (facial) surface
16—third molar, occlusal surface

The lateral walls of the pharynx come into relation with the common and internal carotid arteries, internal jugular vein, nerves, the greater horns of the hyoid bone, and the lamina of the thyroid cartilage.

The upper part of the pharynx is poorly mobile because it is fused with some of the bony structures of the skull; the lower part is very mobile due to the well developed loose areolar tissue surrounding it and filling the **peripharyngeal space** *(spatium pharyngeum)*. This space is bounded medially by the levator veli palatini and tensor veli palatini muscles, the superior constrictor muscle of the pharynx, and the pharyngobasilar fascia; laterally it is bounded by the medial surface of the medial pterygoid muscle and the deep part of the parotid gland; posteriorly are the stylohyoid and stylopharyngeus muscles; anteriorly the medial and lateral walls come into close contact to join along the pterygomandibular ligament *(raphe pterygomandibularis)* below the pterygoid process.

The peripharyngeal space is limited by the base of the skull superiorly and by the fascial sheath of the salivary submandibular gland inferiorly.

The peripharyngeal space is divided in turn into the retrophar-



429. *Cavity of pharynx (cavum pharyngis), right side;* medial aspect ($^2/_3$).
(Sagittal section to the right of the septum of the nose.)

yngeal space and two lateral peripharyngeal spaces (see Fig. 405).

The **retropharyngeal space** *(spatium retropharyngeum)* is a slit situated posteriorly of the pharynx and filled with areolar tissue. It is limited anteriorly by the **buccopharyngeal fascia** *(fascia buccopharyngea)* covering the pharynx and posteriorly by the **prevertebral fascia** *(lamina prevertebralis fasciae cervicalis)*.

The **lateral peripharyngeal space** *(spatium lateropharyngeum)* is found on each side; it is filled with areolar tissue. It is situated laterally and a little to the back of the lateral wall of the pharynx, which is covered by the buccopharyngeal fascia, and medially of the ramus of the mandible, the medial pterygoid muscle, the proximal parts of muscles arising from the styloid process, and the pa-

parotid gland; posteriorly it is bounded by the prevertebral fascia. Each lateral peripharyngeal space contains the internal jugular vein and the internal carotid artery which are embedded in areolar tissue.

Three parts are distinguished in the cavity of the pharynx: an upper, **nasal part of the pharynx** *(pars nasalis pharyngis)*, a middle, **oral part of the pharynx** *(pars oralis pharyngis)*, and a lower, **laryngeal part of the pharynx** *(pars laryngea pharyngis)*.

The upper part of the pharynx is situated between the pharyngeal fornix *(fornix pharyngis)* and the soft palate. The two posterior apertures of the nose *(choanae)* communicating with the cavity of the nose open into the front of the nasal part. On the lateral wall of each nasal part is a funnel-shaped **pharyngeal opening of the pharyngotympanic tube** *(ostium pharyngeum tubae auditivae)* through which it communicates with the cavity of the middle ear. These openings are on a level with the attachment of the posterior end of the inferior nasal concha.

The middle part of the pharynx extends from the soft palate to the inlet of the larynx. The posterior wall of this part corresponds to the third cervical vertebra. During swallowing it is separated from the upper part by the soft palate which takes a horizontal position. On the anterior wall of this part is the **oropharyngeal isthmus** *(isthmus faucium)* by means of which it communicates with the cavity of the mouth.

The lower part of the pharynx stretches behind the larynx from the level of its inlet to the inferior border of the cricoid cartilage at whose level it is continuous with the oesophagus. The posterior wall of the lower part corresponds to the fourth, fifth, and sixth cervical vertebrae. On the anterior wall is the **inlet of the larynx** *(aditus laryngis)* through which the laryngeal part of the pharynx communicates with the cavity of the larynx *(cavum laryngis)*.

The wall of the pharynx consists of three coats: an adventitious (connective-tissue) coat *(tunica adventitia)*, a muscular coat *(tunica muscularis)*, and a mucous coat, or membrane *(tunica mucosa)*.

Between the muscular and mucous coats is the submucous coat *(tela submucosa)* which is characterized by the presence of fibrous tissue. The **adventitious** (connective-tissue) **coat of the pharynx** *(tunica adventitia pharyngis)* is a continuation of the buccopharyngeal fascia *(fascia buccopharyngea)* covering the buccinator muscle and is in turn continuous with the adventitious coat of the oesophagus. Between the adventitious coat of the pharynx and the adjoining organs is a layer of loose connective tissue which is especially developed between the posterior wall of the pharynx and the prevertebral fascia. It is called here the retropharyngeal areolar tissue and fills the retrovisceral space *(spatium retroviscerale)*.

The **muscular coat of the pharynx** *(tunica muscularis pharyngis)*, or the muscular layer, is formed of five layers of striated muscles. Three of them are muscles constricting the pharynx *(musculi constrictores pharyngis)* and stretching transversally, and two are muscles raising the pharynx and passing longitudinally. The three pairs of constrictors of the pharynx meet posteriorly on the midline and partly pass over to the contralateral side and interlace with a longitudinal connective-tissue band arising from the pharyngeal tubercle *(tuberculum pharyngeum)* and called the **raphe of the pharynx** *(raphe pharyngis)*.

THE MUSCLES OF THE PHARYNX

1. The **superior constrictor muscle of the pharynx** *(musculus constrictor pharyngis superior)* (Figs 430–433) is a quadrangular sheet. It arises from several areas according to which the following four parts (or muscles) are distinguished in it:

(a) the **pterygopharyngeal part of the superior constrictor muscle of the pharynx** *(pars pterygopharyngea musculi constrictoris pharyngis superioris)* arising from the pterygoid hamulus and medial pterygoid plate;

(b) the **buccopharyngeal part of the superior constrictor muscle of the pharynx** *(pars buccopharyngea musculi constrictoris pharyngis superioris)* arising from the pterygomandibular ligament *(raphe pterygomandibularis)*;

(c) the **mylopharyngeal part of the superior constrictor muscle of the pharynx** *(pars mylopharyngea musculi constrictoris pharyngis superioris)* arising from the posterior end of the mylohyoid line of the mandible *(linea mylohyoidea mandibulae)*;

(d) the **glossopharyngeal part of the superior constrictor muscle of the pharynx** *(pars glossopharyngea musculi constrictoris pharyngis superioris)* arising from the root of the tongue.

The muscle fibres pass horizontally on the lateral wall of the pharynx to the posterior wall to meet with the fibres of the contralateral muscle in the raphe of the pharynx. The upper border of the muscle does not reach the base of the skull and the area of the pharyngeal wall devoid of the muscular coat consists of a thickened submucous framework of the pharynx called the **pharyngobasilar fascia** *(fascia pharyngobasilaris)*.

2. The **middle constrictor muscle of the pharynx** *(musculus constrictor pharyngis medius)* (Figs 430–432) consists of the following two parts (or muscles):

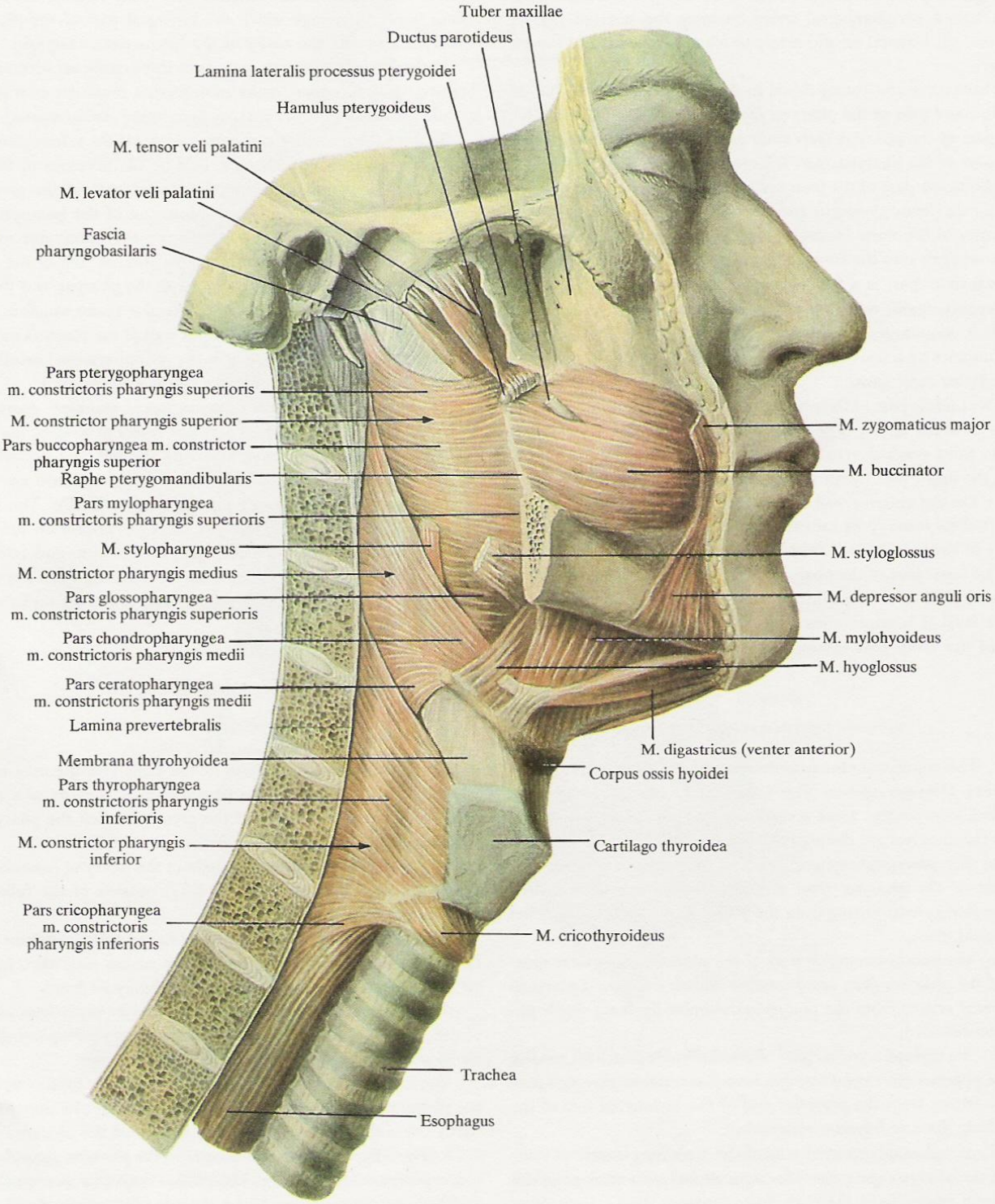
(a) the **chondropharyngeal part of the middle constrictor muscle of the pharynx** *(pars chondropharyngea musculi constrictoris pharyngis medii)* arises from the lesser horn of the hyoid bone;

(b) the **ceratopharyngeal part of the middle constrictor muscle of the pharynx** *(pars ceratopharyngea musculi constrictoris pharyngis medii)* arises from the greater horn of the hyoid bone.

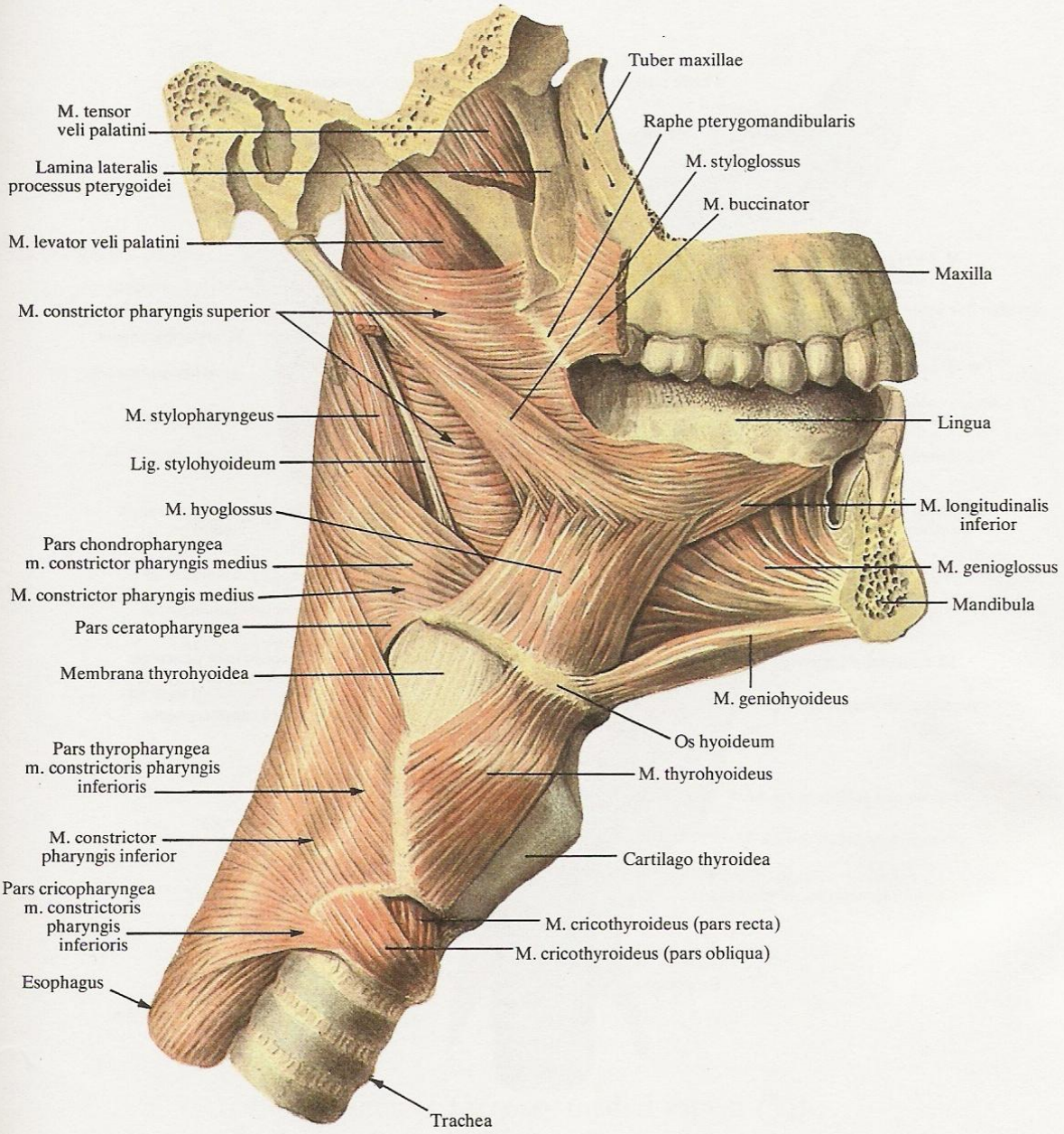
The muscle is a triangular sheet whose base is on the raphe of the pharynx while the apex faces the hyoid bone. Its upper fibres partly cover the superior constrictor muscle of the pharynx.

3. The **inferior constrictor muscle of the pharynx** *(musculus constrictor pharyngis inferior)* (Figs 430–432) is flat and covers partly the middle constrictor muscle of the pharynx. It consists of two parts (or muscles):

(a) the **thyropharyngeal part of the inferior constrictor muscle of the pharynx** *(pars thyropharyngea musculi constrictoris pharyngis infe-*



430. *Muscles of pharynx (musculi pharyngis);* from right side ($^4/_5$).



431. *Muscles of pharynx and tongue;* from right side ($^1/_1$).

rioris) arises from the outer surface of the lamina of the thyroid cartilage of the larynx;

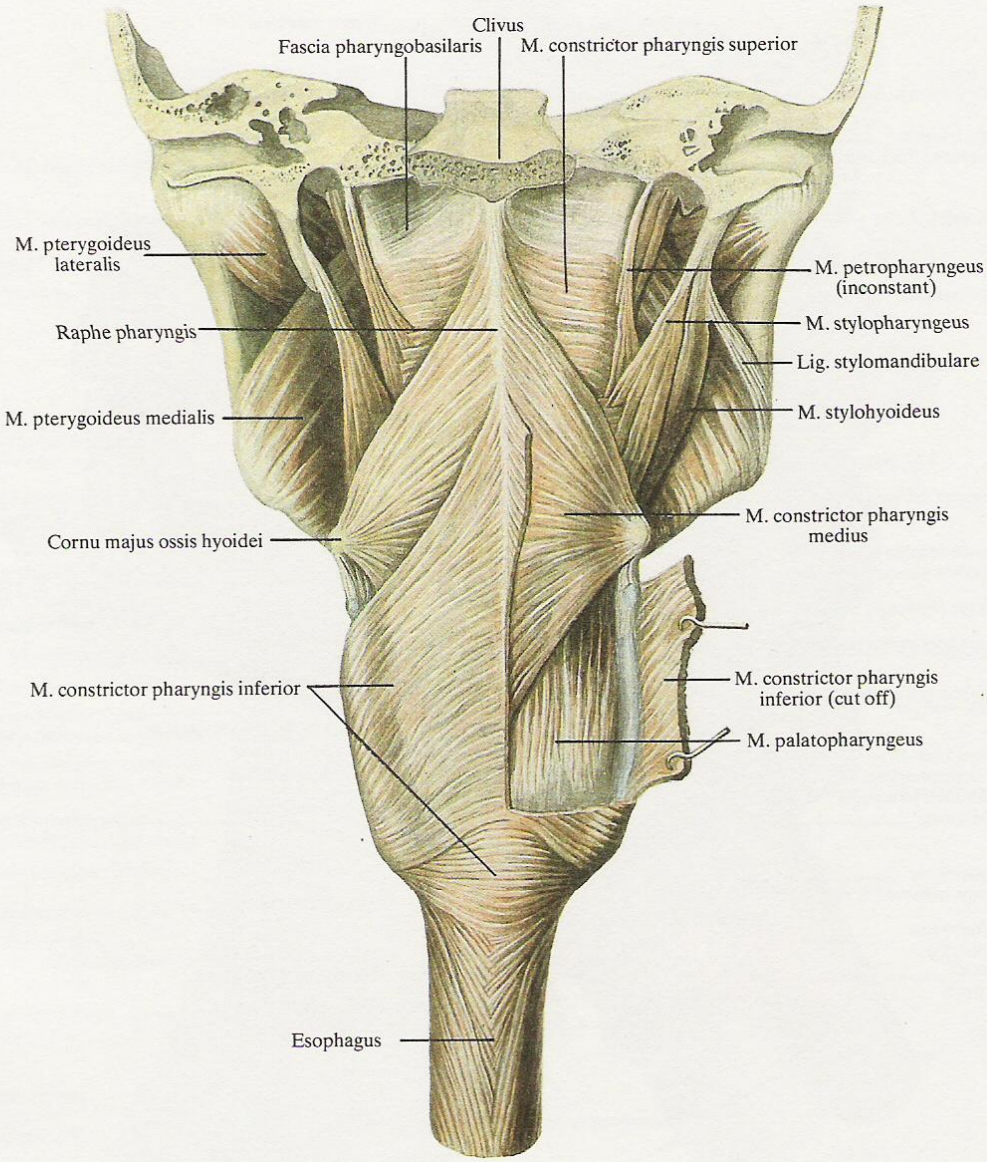
(b) the **cricopharyngeal part of the inferior constrictor muscle of the pharynx** *(pars cricopharyngea musculi constrictoris pharyngis inferioris)* arises from the lateral surface of the cricoid cartilage of the larynx.

The muscle fibres spread out fan-like to meet the fibres of the contralateral muscle on the raphe of the pharynx.

The action of the muscles described consists in constriction of the pharynx.

Innervation: the pharyngeal plexus *(plexus pharyngeus)*.

Blood supply: the ascending pharyngeal and the ascending pal-



432. *Muscles of pharynx;* posterior aspect ($^3/_4$).

atine arteries (*arteriae pharyngea ascendens* et *palatina ascendens*).

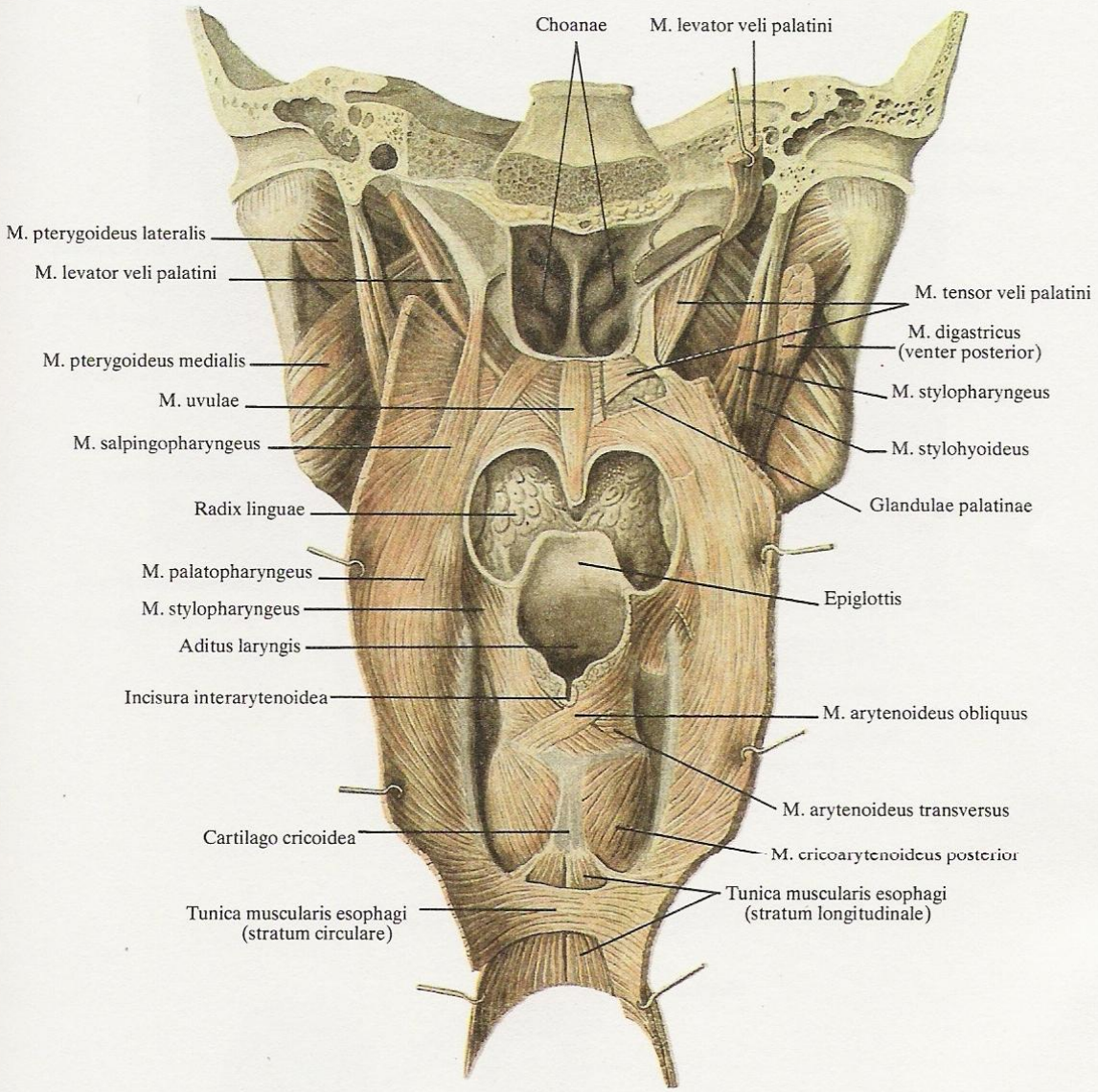
4. The **stylopharyngeus muscle** *(musculus stylopharyngeus)* (Figs 431–433) is narrow and long and arises from the styloid process, runs downwards on the wall of the pharynx, penetrates it between the superior and the middle constrictor muscles of the pharynx, and separates into fibres some of which blend with the wall of the pharynx and the others reach the cartilages of the larynx.

Action: raises the pharynx and the larynx.

Innervation: the glossopharyngeal nerve *(nervus glossopharyngeus)*.

Blood supply: the ascending pharyngeal and the ascending palatine arteries (*arteriae pharyngea ascendens* et *palatina ascendens*).

5. The **palatopharyngeus muscle** *(musculus palatopharyngeus)* (Fig. 433) (see *The Muscles of the Palate and Fauces*).



433. *Muscles of pharynx;* medial aspect ($^3/_4$).

(The posterior pharyngeal wall is opened by midsagittal incision, the mucous membrane is removed.)

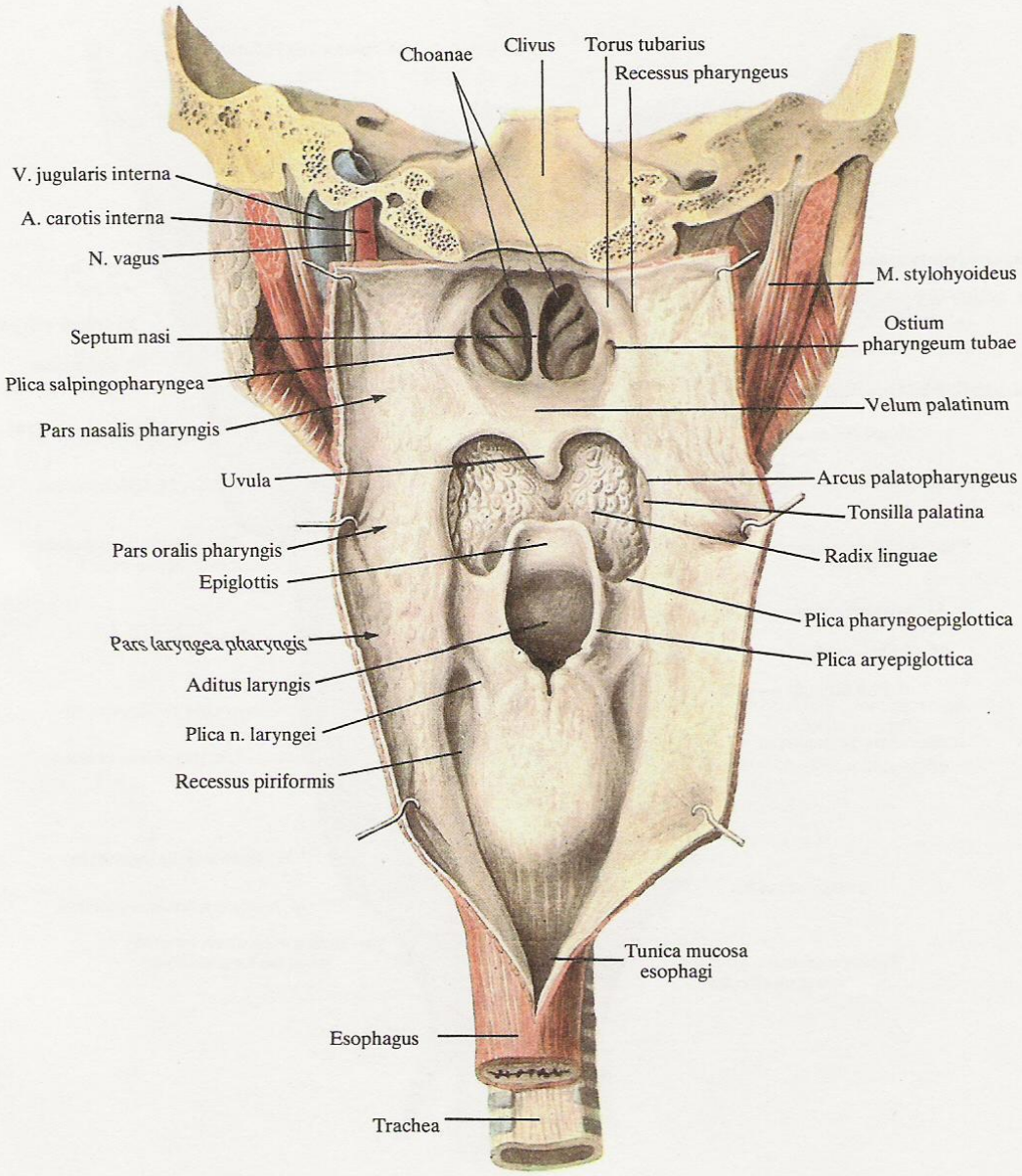
THE MUCOUS COAT OF THE PHARYNX

The **submucous coat of the pharynx** *(tela submucosa pharyngis)* is a well formed sheet of fibrous tissue. Its upper, thickest part is called the **pharyngobasilar fascia** *(fascia pharyngobasilaris)* and is attached to the external surface of the base of the skull.

Lymph glands embedded under the mucous coat form accumulations of lymphoid tissue on the posterior wall of the upper pharynx and at the openings of the pharyngotympanic tubes—the **nasopharyngeal tonsil** *(tonsilla pharyngea)* (Fig. 429) and two **tube tonsils** *(tonsillae tubariae)*.

The lingual, palatine, tube, and nasopharyngeal tonsils form a lympho-epithelial ring (Waldeyer's tonsillar ring).

The **mucous coat (membrane) of the pharynx** *(tunica mucosa*



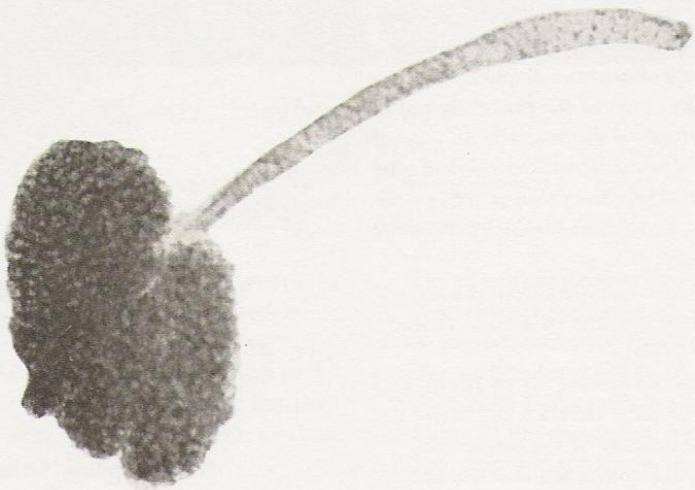
434. *Cavity of pharynx;* inner aspect ($^3/_4$).
(Posterior pharyngeal wall is opened by midsagittal incision.)

pharyngis) (Fig. 434) is a continuation of the mucous membrane of the cavities of the nose and mouth and is continuous downwards with the mucous coat of the larynx and oesophagus.

The mucous coat is covered by stratified ciliated epithelium in the upper part of the pharynx and with stratified squamous epithelium in the other parts. It is closely fused with the mucous coat.

In the upper part of the pharynx, in the region of the **pharyngeal opening of the pharyngotympanic tube** *(ostium pharyngeum tubae auditivae)* (Figs 429, 434) the mucous membrane forms two folds which meet at the opening. The cartilage of the pharyngotympanic tube, which forms the **tubal elevation** *(torus tubarius)*, is embedded in one of them. This fold is continuous downwards with a gradually thinned out mucous **salpingopharyngeal fold** *(plica sal-*

435A. *Pharyngeal glands* (specimen prepared by V. Malishevskaya).
(Photomicrograph.)
(Group of glands from totally stained wall of whole pharynx.)



435B. *Pharyngeal gland* (specimen prepared by V. Malishevskaya).
(Photomicrograph.)

pingopharyngea). A short **salpingopalatine fold** *(plica salpingopalatina)* stretches from the second fold to the soft palate.

Posteriorly of the tubal elevation is a small cavity called the **recess of the pharynx** *(recessus pharyngeus)*.

In the lower part of the pharynx is a fossa situated between the medial surface of the thyroid cartilage of the larynx and the aryepiglottic fold *(plica aryepiglottica)*; it is called the **piriform fossa** *(recessus piriformis)*. In the region of this fossa, above the superior laryngeal nerve *(nervus laryngeus superior)* passing here, the mucous membrane forms the **fold of the laryngeal nerve** *(plica nervi laryngei)*.

The mucous **pharyngeal glands** *(glandulae pharyngeae)* (Figs 435 A, 435 B) of various size and shape which are embedded in the submucous coat open on the surface of the mucous coat.

THE OESOPHAGUS

The **oesophagus** *(esophagus)* (Figs 436, 437) has the appearance of a tube connecting the pharynx with the stomach. In an adult the junction between the pharynx and the oesophagus corresponds to the level of the sixth cervical vertebra or the inferior border of the cricoid cartilage. The junction with the stomach is projected on a level with the eleventh thoracic vertebra. In the newborn the beginning of the oesophagus is on a level with the fourth or fifth cervical vertebra while the end is on a level with the eleventh thoracic vertebra. These boundaries may alter in a living human when he flings back his head or takes a deep breath, and in a person with gastroptosis.

The oesophagus is 10 to 16 cm in length in the newborn, 20 cm by the age of 2 years, and up to 25 cm in an adult.

A small part of the oesophagus is situated in the region of the neck, after which it descends through the inlet of the thorax *(apertura thoracis superior)* into the thoracic cavity, passes in it, and then leaves it through the oesophageal opening of the diaphragm *(hiatus esophageus diaphragmatis)* to enter the cavity of the abdomen and to be continuous with the cardiac portion of the stomach. In view of this, the following three parts are distinguished: the **cervical part of the oesophagus** *(pars cervicalis esophagi)*, the **thoracic part of the oesophagus** *(pars thoracica esophagi)*, and the **abdominal part of the oesophagus** *(pars abdominalis esophagi)*.

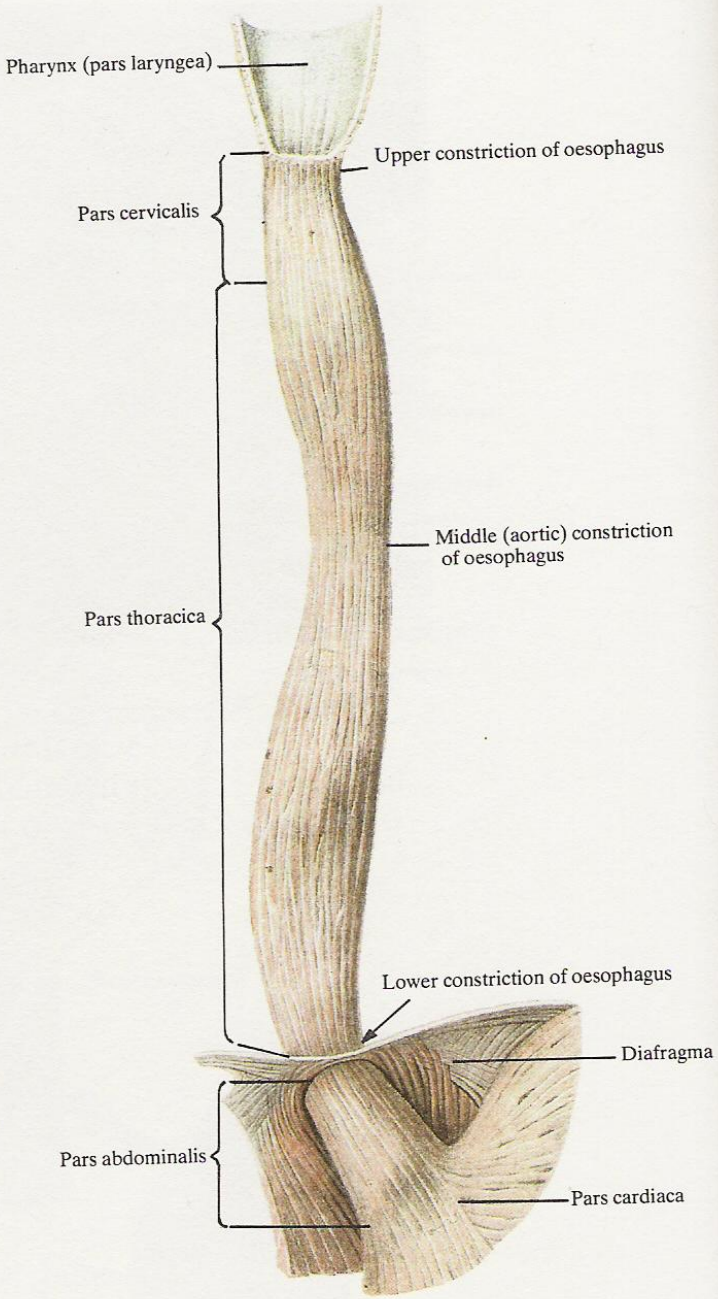
The cervical part of the oesophagus stretches from the level of the sixth cervical vertebra to that of the first or second thoracic vertebra. Its length ranges from 5 to 8 cm.

The thoracic part is the longest, measuring 15 to 18 cm, and ends on a level with the tenth or eleventh vertebra, i. e. where the oesophagus enters the oesophageal opening of the diaphragm.

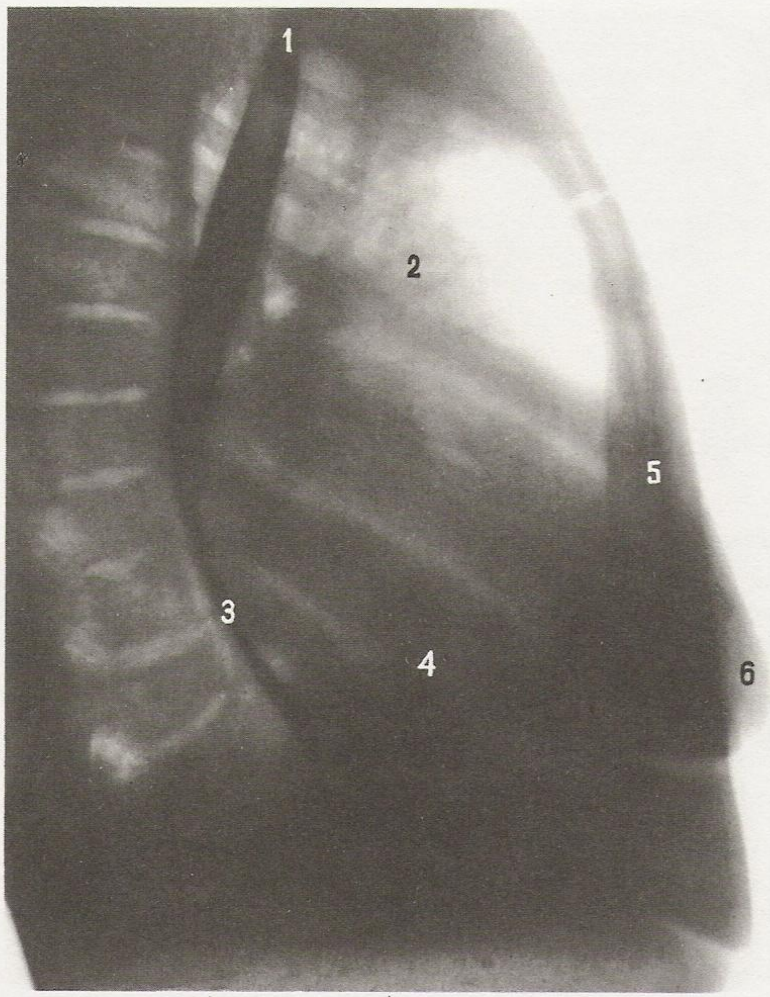
The abdominal part of the oesophagus is the shortest and its length varies from 1 to 3 cm. At the junction with the stomach the oesophagus is slightly dilated.

The oesophagus stretches in front of the vertebral column and forms four curves: two in the sagittal and two in the frontal planes.

The beginning of the oesophagus is almost strictly on the midline but at the level of the second thoracic vertebra it deviates to



436. *Oesophagus (esophagus);* anterior aspect ($^1/_2$).



437. *Oesophagus;* right side (radiograph).

1—upper constriction
2—anterior mediastinum
3—lower constriction
4—dome of diaphragm
5—sternum
6—mammary gland

the left and in the region of the third and fourth vertebrae occupies an extreme left position. At the level of the fifth vertebra it again stretches on the midline but distally deviates to the right, being pushed aside by the aorta. The curve to the right extends to the level of the eighth thoracic vertebra. Running downwards the oesophagus again deviates to the left at the level of the eighth to ninth vertebrae, where it passes through the diaphragm.

The lumen of the oesophagus varies along its length and three constrictions and two dilations are distinguished in it. The first constriction is where the pharynx is continuous with the oesophagus, the second is where the oesophagus is related to the aorta, and the third constriction is at the site of its passage through the oesophageal opening of the diaphragm. Between these constrictions are two dilations.

The oesophagus comes into relation with a series of organs.

The posterior surface of the cervical part of the oesophagus lies on the prevertebral fascia to which it is joined by areolar tissue; the anterior surface is related to the membranous wall of the trachea. On both sides the oesophagus is approached by the common carotid arteries and the reccurrent laryngeal nerves.

The posterior surface of the thoracic part of the oesophagus also stretches along the vertebral column while the upper third of the anterior surface is related to the membranous wall of the trachea. On the level of the fourth-fifth vertebra the oesophagus crosses the arch of the aorta below which it is related to the posterior surface of the left bronchus to which it is connected by a poorly developed **broncho-oesophageal muscle** *(musculus bronchoesophageus)*.

438A. *Oesophageal glands* (specimen prepared by F. Zinovyeva). (Photomicrograph.)
(Group of glands from totally stained wall of whole oesophagus.)

438B. *Oesophageal gland* (specimen prepared by F. Zinovyeva). (Photomicrograph.)
(Gland isolated from totally stained wall of whole oesophagus.)

The lower third of the oesophagus comes in contact with an area of the pericardium corresponding to the left atrium and left ventricle, then runs downwards, curving spirally about the aorta, and continues as the abdominal part which is covered in front by an area of the left lobe of the liver.

The wall of the oesophagus consists of three coats: mucous, muscular, and adventitious; the abdominal part is covered, in addition, with a serous coat.

The **mucous coat of the oesophagus** *(tunica mucosa esophagi)* is covered by stratified squamous epithelium. It is formed of areolar tissue and a well developed lamina muscularis mucosae of smooth fibres whose role consists in contracting the mucous coat during constriction of the oesophagus.

On a transverse section the oesophageal lumen is seen as a stellate slit due to the compressed walls and the well-pronounced longitudinal folds. The size of the folds is linked with the strongly developed areolar tissue forming the **submucous coat of the oesophagus** *(tela submucosa esophagi)* situated between the mucous and muscular coats. The submucous coat contains many vessels and the mucous **oesophageal glands** *(glandulae esophageae)* (Figs 438 A, 438 B), whose ducts open on the surface of the mucous coat, and occasional lymph follicles.

The **muscular coat of the oesophagus** *(tunica muscularis esophagi)* consists of two layers: an inner, circular and an outer, longitudinal layer. Vascular and nerve networks are lodged in the loose connective tissue between the layers.

The muscular layers are represented in the upper third of the oesophagus by striated musculature, in the middle third by striated and smooth musculature, and finally, in the lower third by smooth musculature alone.

The layers of muscles are developed irregularly. The longitudinal muscles for instance, are composed of longitudinal fibres forming two bands in the upper part of the oesophagus which are inserted into the cricoid cartilage of the larynx. An area devoid of the longitudinal layer remains therefore in the initial part of the oesophagus. The circular layer of the oesophageal wall is connected with the muscles of the pharynx in the upper parts and is continuous with the circular and oblique fibres of the muscular

coat of the stomach. A poorly-developed longitudinal layer lying inwardly of the circular layer can be seen at places along the length of the oesophagus.

The muscular coat of the oesophagus gives off processes which as slips connect it to the adjoining organs. Where the oesophagus passes through the diaphragm its muscle fibres are closely joined to those of the diaphragm as a result of which a circular muscle resembling a sphincter forms around the oesophagus.

The **adventitious coat of the oesophagus** *(tunica adventitia esophagi)* is formed of loose connective tissue containing a few elastic fibres. By means of this coat the oesophagus is attached to the other organs situated around it in the posterior mediastinum. The main vessels supplying blood to the oesophagus, lymph vessels draining the oesophageal walls, as well as nerves forming plexuses pass within the adventitious coat.

Innervation: the oesophageal plexus *(plexus esophagei)*.

Blood supply: in the cervical part—the inferior thyroid artery *(arteria thyroidea inferior)*; in the thoracic part—the oesophageal and bronchial arteries (*arteriae esophageae* et *bronchiales*); in the abdominal part—the left gastric and phrenic arteries *(arteriae gastrica sinistra* et *phrenica inferior)*.

THE ABDOMINAL AND PELVIC PARTS OF THE SYSTEM OF DIGESTIVE ORGANS

THE STOMACH

The **stomach** (*ventriculus* s. *gaster*) (Figs 439–443) is situated in the upper left (⅚) and right (⅙) parts of the abdominal cavity. Its long axis passes downwards from left to right and from back to front, almost in the frontal plane. The shape and size of the stomach are quite variable and are determined by the degree of its filling, the functional condition of the musculature of its walls (contraction, relaxation), distention of the large and small intestine, and other factors.

The shape of the stomach also changes with age. It is usually compared to a retort placed upside down with the wide left part situated under the diaphragm and the narrow part, under the liver. The length of the stomach along its long axis measures 21–25 cm on the average. Its capacity reaches 3 litres.

The stomach has several parts: the cardiac portion, the fundus, the body, and the pyloric portion.

The **cardiac portion of the stomach,** or **cardia** *(pars cardiaca ventriculi)* begins by an opening through which the oesophagus communicates with the stomach; this is the **cardiac orifice** *(ostium cardiacum)*. The part of the stomach in close vicinity to the orifice is the cardiac portion.

Immediately to the left of the cardiac portion is a convex part called the **fundus of the stomach** (*fundus* s. *fornix ventriculi*). The largest and widest part is the **body of the stomach** *(corpus ventriculi)* which is continuous upwards with the fundus without any apparent boundaries; as it stretches to the right it gradually becomes narrower to be continuous with the pyloric portion.

The **pyloric portion of the stomach** *(pars pylorica ventriculi)* is the distal part of the stomach immediately adjacent to the **pyloric orifice** *(ostium pyloricum)* by means of which the stomach communicates with the duodenum.

The pyloric portion consists of the **pyloric antrum** *(antrum pyloricum)*, which is the widest and contiguous with the body part, and a narrow part called the **pyloric canal** *(canalis pyloricus)* whose diameter is the same as that of the adjacent part of the small intestine (the duodenum).

The cardiac portion, fundus, and body make up that part of the stomach which stretches downwards and to the right; the pyloric portion is the part which is directed upwards and to the right at an angle to the body of the stomach. At the junction with the pyloric antrum the body forms the lowest part of the cavity of the stomach.

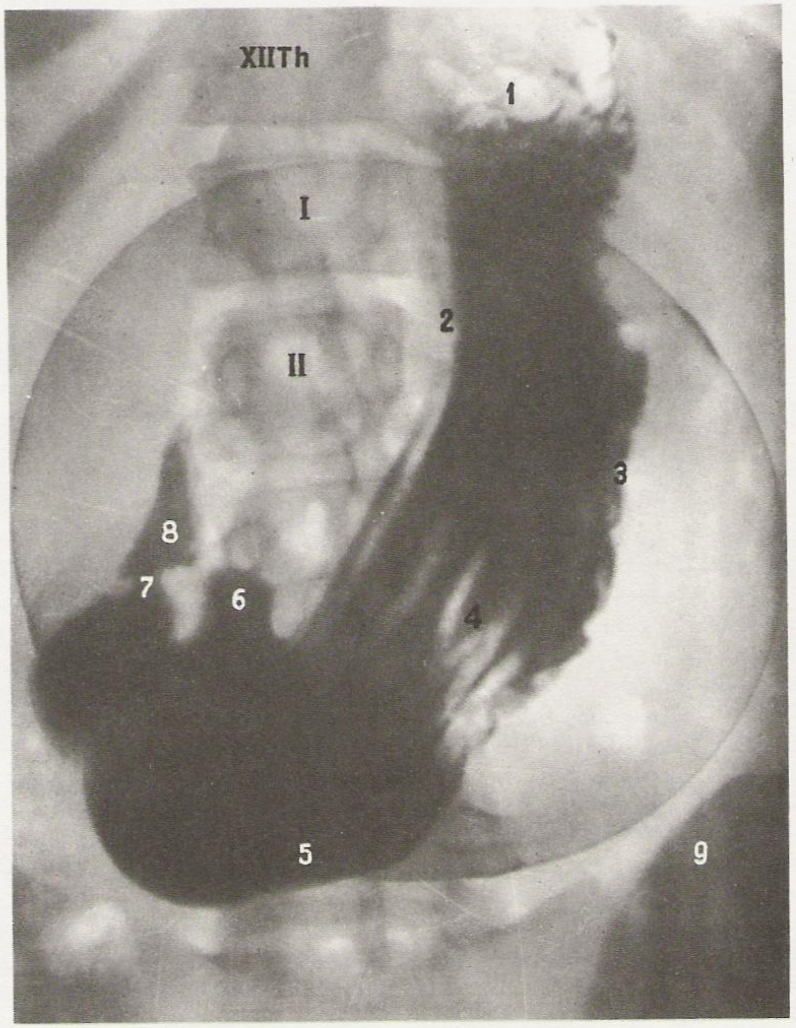
The described shape of the stomach is encountered more frequently during X-ray examination and is compared to the shape of a fish-hook; another shape that can be seen on X-ray examination is that of a horn, in which case the body of the stomach lies almost transversely while the pyloric part is its continuation without angulation.

The surface of the stomach facing the front is the **anterior wall of the stomach** *(paries anterior ventriculi)*, that facing the back is the **posterior wall of the stomach** *(paries posterior ventriculi)*. The upper border of the stomach at the junction of the anterior and posterior walls is concave, shorter, and forms the **lesser curvature of the stomach** *(curvatura ventriculi minor)*. The lower border forming the lower junction of the walls of the stomach is convex and longer and is the **greater curvature of the stomach** *(curvatura ventriculi major)*.

At the junction of the body of the stomach with the pyloric portion the lesser curvature forms the **angular notch** *(incisura angularis)* while the greater curvature bears no noticeable marking here. Only during the digestion of food the body is separated from the pyloric portion (antrum) by a deep fold, which can be seen on X-ray. This constriction is usually seen on a cadaver also. The greater curvature bears the **cardiac notch** *(incisura cardiaca)* separating the cardiac portion from the fundus.

The wall of the stomach consists of three coats: outer—the peritoneum (serous coat), middle—muscular, and inner—mucous.

The **serous coat of the stomach** *(tunica serosa ventriculi)* (Fig. 440) is the visceral peritoneum enclosing the stomach, whose position, consequently, is intraperitoneal. Only narrow bands on the lesser and greater curvatures remain uncovered where the



439. *Stomach* (radiograph).

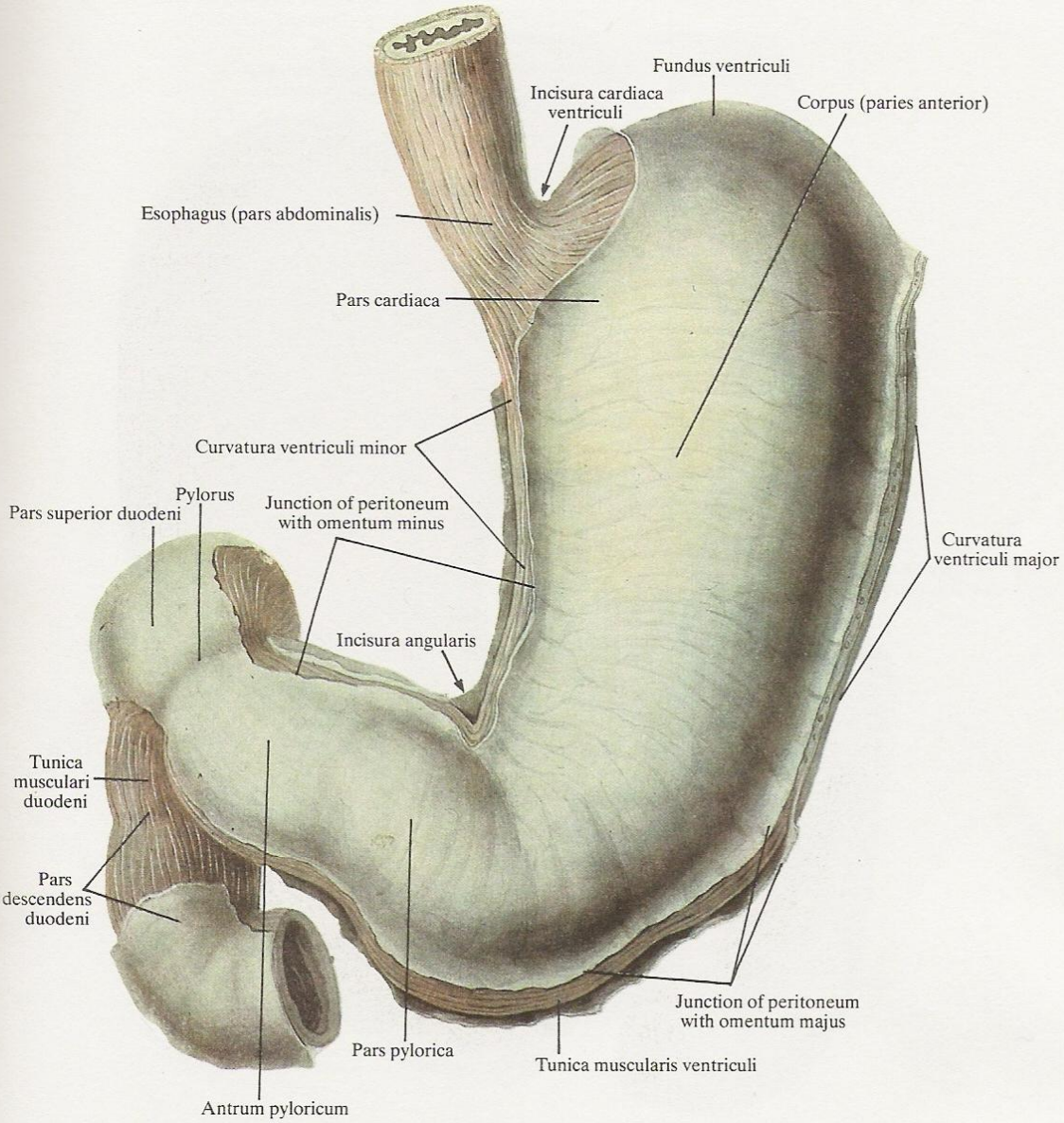
1—fundus of stomach
2—lesser curvature of stomach
3—greater curvature of stomach
4—body of stomach (contrast medium between folds of mucous coat of stomach)
5—upper extremity of stomach
6—peristalsis wave
7—pylorus
8—duodenal bulb
9—iliac crest
XIITh—twelfth thoracic vertebra
IL—first lumbar vertebra
IIL—second lumbar vertebra

sheets of peritoneum covering the anterior and posterior walls meet to form the peritoneal ligaments of the stomach. Along the curvatures between the sheets of peritoneum pass blood and lymph vessels, the nerves of the stomach, and regional lymph nodes are invested.

A small area of the posterior wall of the stomach to the left of the cardiac portion, where the wall is in contact with the diaphragm, is not covered by the peritoneum. A peritoneal fold arising from the extreme left part of the lesser curvature passes to the diaphragm; this is the gastrophrenic ligament *(ligamentum gastrophrenicum)*. Its right segment runs to the inferior surface of the liver and forms the hepatogastric ligament *(ligamentum hepatogastricum)* which is continuous further to the right with a ligament connecting the first part of the duodenum with the porta hepatis and is called the hepatoduodenal ligament *(ligamentum hepatoduodenale)*.

These three ligaments make up the lesser omentum *(omentum minus)*.

The peritoneal fold arising from the greater curvature on the left side connects the fundus of the stomach with the spleen and is known as the gastrosplenic ligament *(ligamentum gastrolienale)* (see Fig. 476); the splenic vessels and nerves pass in it. From the greater curvature of the body of the stomach and the pyloric portion

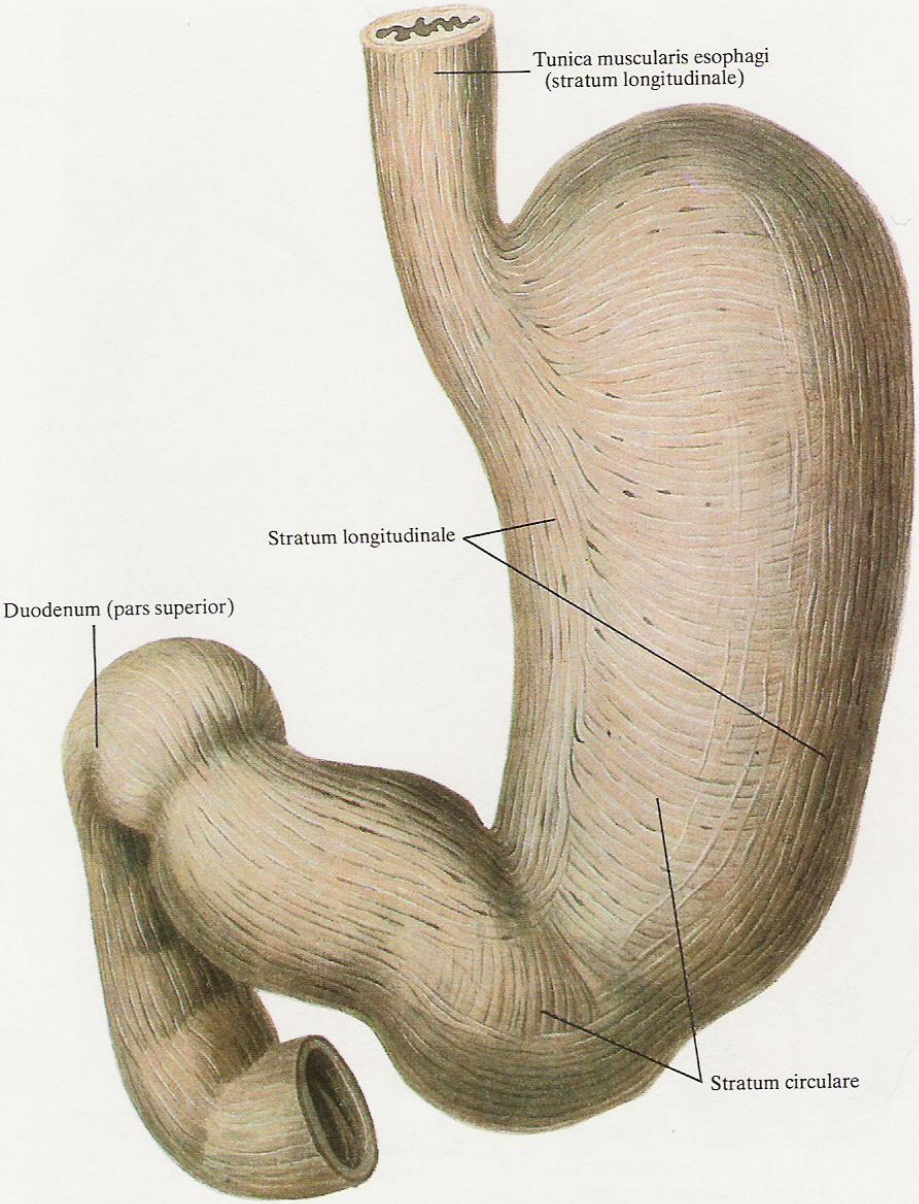


440. *Stomach (ventriculus) and duodenum* ($^1/_2$).
(Anterior wall of stomach.)

stretches the gastrocolic ligament *(ligamentum gastrocolicum)* to the transverse colon. Below the level of the transverse colon this ligament descends in front of the intestinal loops to the true pelvis and thus forms the anterior two layers of the greater omentum *(omentum majus)* (see Fig. 474).

The **muscular coat of the stomach** *(tunica muscularis ventriculi)* consists of three layers: outer (longitudinal), middle (circular), and deep (oblique).

The outer, **longitudinal layer** *(stratum longitudinale)* is a continuation of the longitudinal layer of the oesophagus and is thickest

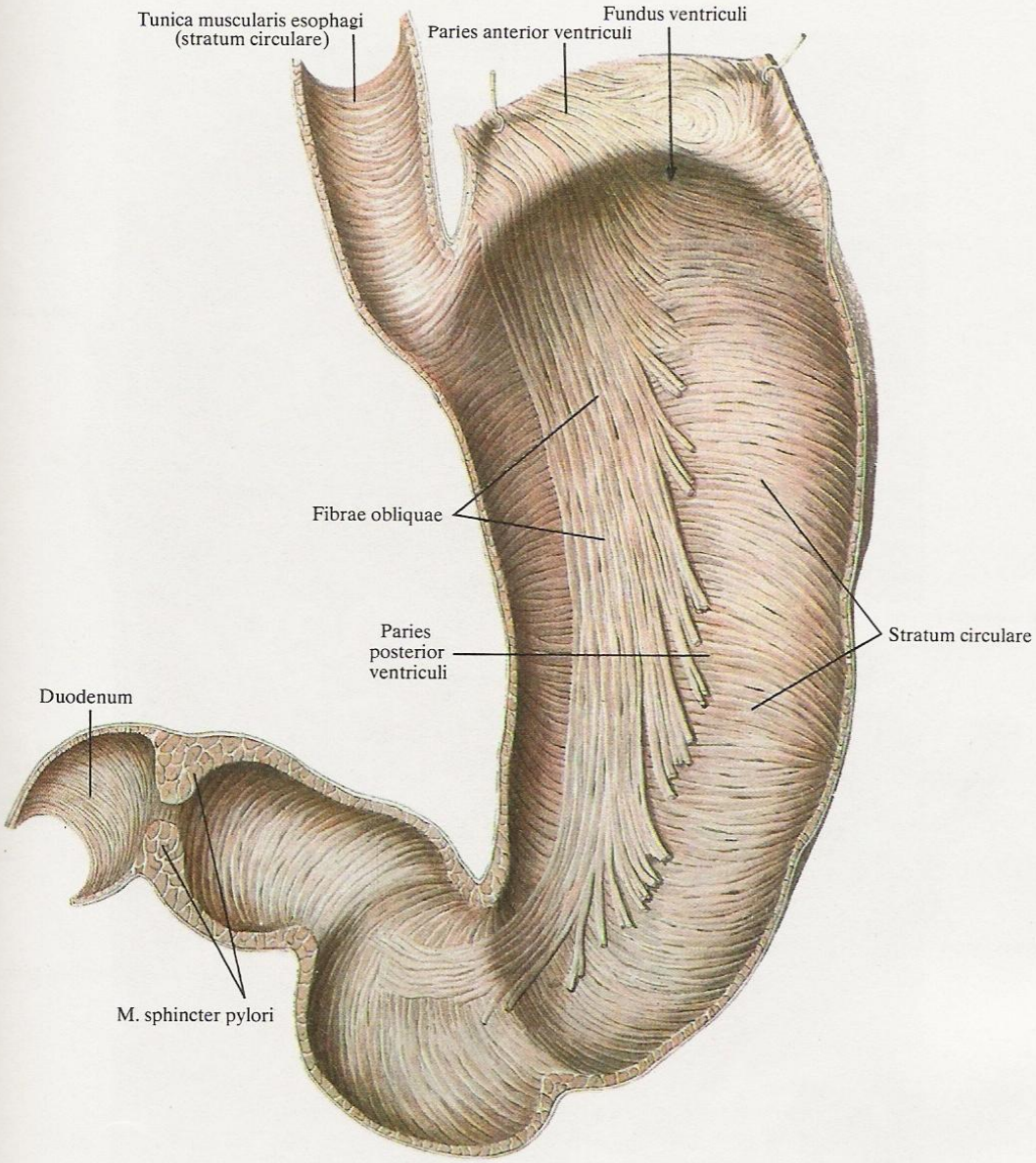


441. *Muscular coat of stomach and duodenum (tunica muscularis ventriculi et duodeni)* ($^1/_2$).

(Serous coat is removed.)

in the region of the lesser curvature. Where the body of the stomach is continuous with the pyloric portion the fibres of the longitudinal layer spread out fanwise on the anterior and posterior walls of the stomach and interlace with the fibres of the next, circular layer. In the region of the greater curvature and fundus the longitudinal muscle fibres form a thinner layer but over a larger area.

The middle, **circular layer** *(stratum circulare)* is a continuation of the circular layer of the oesophagus. It is an uninterrupted layer enclosing the stomach completely and is less developed in the re-

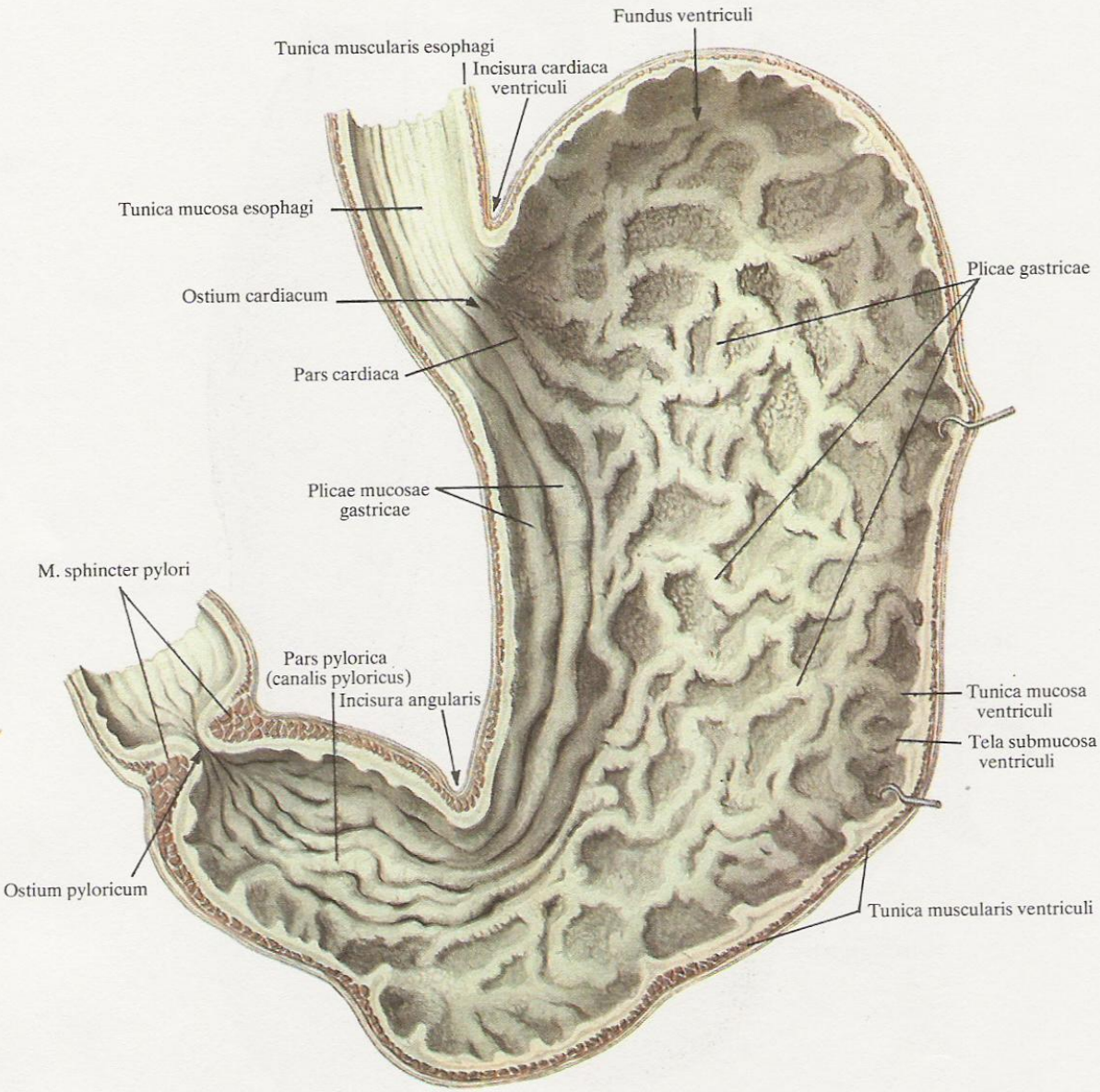


442. *Muscular coat of stomach;* inner surface of posterior wall ($^1/_2$).
(Mucous and submucous coats are removed.)

gion of the fundus but forms a pronounced thickenings called the pyloric sphincter *(musculus sphincter pylori)* in the region of the pylorus (Fig. 443).

The inner layer is formed of **oblique fibres** *(fibrae obliquae)* (Fig. 442) occurring not as continuous layer but in separate groups. The muscular bundles embrace the cardiac portion of the stomach like a loop and pass over to the anterior and posterior walls of the body. Contraction of this muscular loop is just what is responsible for the presence of the cardiac notch *(incisura cardiaca)*. In the vicinity of the lesser curvature the oblique fibres change to longitudinal.

The **mucous coat, or membrane, of the stomach** *(tunica mucosa ventriculi)* is a continuation of the mucous coat of the oesophagus. An easily detectable serrated line is the boundary between the epi-

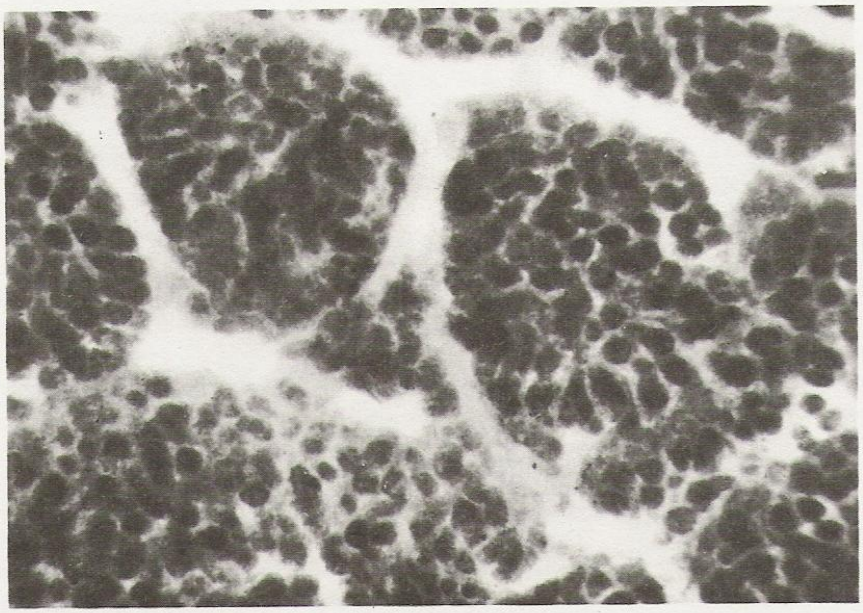


443. *Mucous coat (membrane) of stomach (tunica mucosa ventriculi);* inner surface of posterior wall ($^1/_2$).

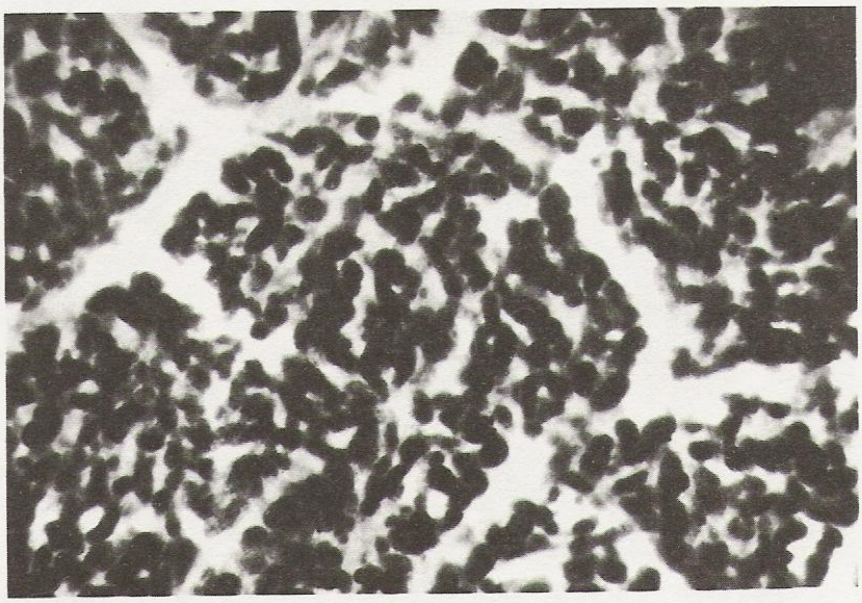
thelium of the mucous membrane of the oesophagus and that of the stomach. A fold of mucous membrane is always present at the level of the pylorus corresponding to the position of the sphincter. The mucous coat of the stomach is 1.5 to 2 mm thick. It forms very many **gastric folds** *(plicae gastricae)*, mainly on the posterior wall.

The folds differ in length and direction: close to the lesser curvature there are long longitudinal folds which limit a smooth area of the mucous membrane known as the gastric gutter. The folds on the other areas of the wall vary greatly in direction, and longer folds connected to one another by shorter folds are distinguished. The direction and number of longitudinal folds are more or less constant and in a living person are easily detected on X-ray examination with contrast media. When the stomach is distended the folds are smoothed out.

A



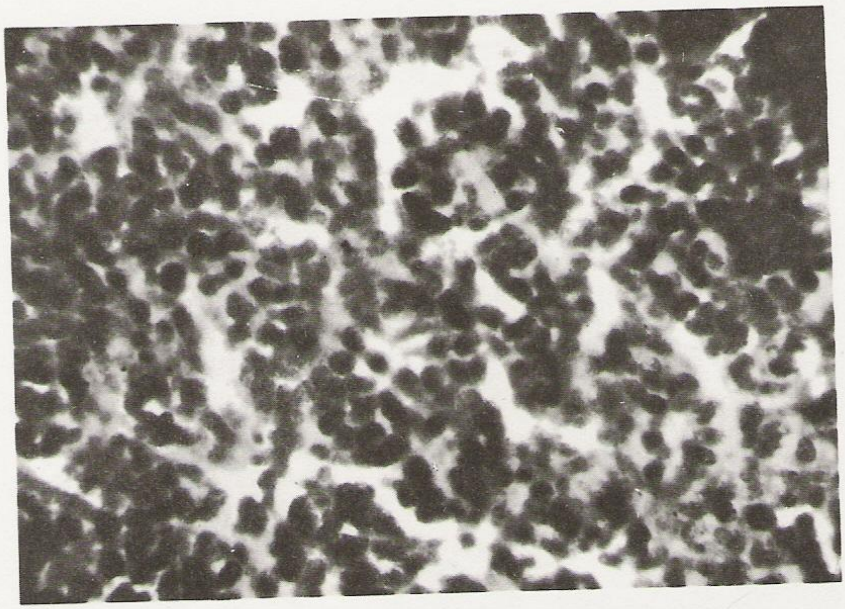
B



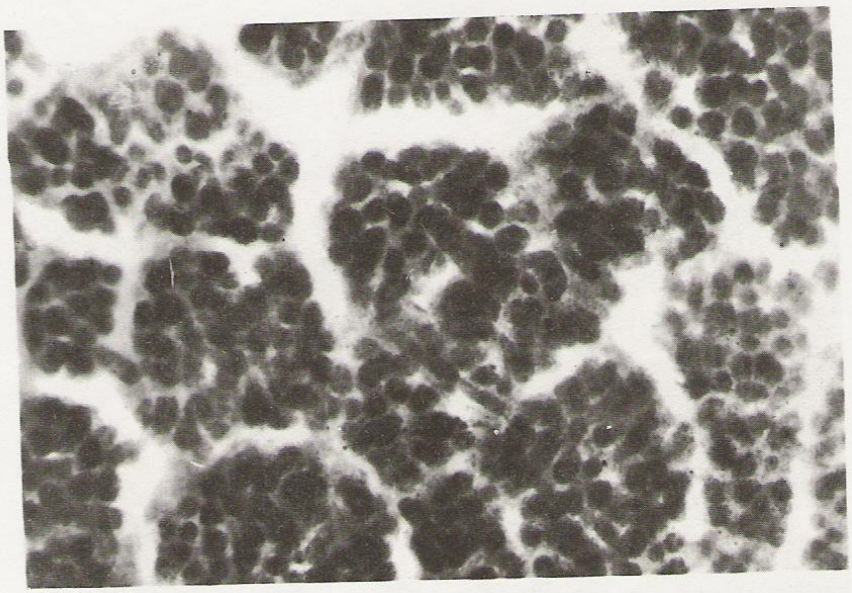
444. *Glands of mucous coat of stomach* (specimens prepared by V. Popova). (Photograph, × 12.)

(Area of totally stained mucous coat of stomach.)

A—region of lesser curvature, middle parts (12-year-old boy).
B—region of lesser curvature, nearer to pylorus (15-year-old boy).



C



D

444 (continued). *Glands of mucous coat of stomach* (specimens prepared by V. Popova). (Photograph, × 12.)
(Area of totally stained mucous coat of stomach.)
C—region of fundus (15-year-old boy),
D—region of body (12-year-old boy).

The mucous coat of the stomach has its own **lamina muscularis mucosae** and is separated from the muscular coat by a well developed loose **submucous coat** *(tela submucosa)*; these two coats are responsible for the formation of the folds.

The mucous coat of the stomach is divided into small, 1 to 6 mm in diameter, **gastric areas** *(areae gastricae)* (Fig. 444) on which are small 0.2 mm wide pits called **gastric foveolae** *(foveolae gastricae)*. The foveolae are surrounded by **villous folds** *(plicae villosae)* which are most pronouced in the region of the pylorus. One or two ducts of the gastric glands open in each foveola. **Gastric glands proper** *(glandulae gastricae propriae)* occurring in the region of the fundus and body and consisting of chief and parietal cells, and **pyloric glands** *(glandulae pyloricae)*, consisting of chief cells alone, are distinguished. **Gastric lymphatic nodules** *(folliculi lymphatici gastrici)* are embedded in the mucous coat (predominantly in the pyloric portion).

Topography of the stomach. The greater part of the stomach is situated to the left of the midplane of the body, occupying the left hypochondric and epigastric regions.

Skeletopically, the entry into the stomach is to the left of the vertebral column on a level with the tenth or eleventh thoracic vertebra; the exit is to the right of the vertebral column on a level with the twelfth thoracic or first lumbar vertebra.

The upper (vertical in a horn-shaped stomach) part of the lesser curvature stretches along the left border of the vertebral column, the lower part crosses the vertebral column from left to right.

The posterior wall of the stomach in the region of the fundus is in relation with the spleen; the other parts of the posterior wall adjoin organs situated at the back of the abdomen: the left suprarenal gland, the upper end of the left kidney, the pancreas, the aorta and the vessels arising from it.

The stomach is displaced during respiration and when the adjacent hollow organs (the transverse colon) are filled. The cardiac and pyloric portions of the stomach are less mobile, the other portions are distinguished by considerable ability to displace. The lowest point (lower pole) of the greater curvature in a hook-like shape and vertical position of the stomach descends to the level of a line drawn between the iliac spines *(linea biiliaca)* and sometimes lies below it.

The fundus of the stomach is below the dome of the left half of the diaphragm. The lesser curvature and upper portion of the anterior wall are in relation with the inferior surface of the left lobe of the liver. The anteroinferior surface of the body and pyloric portion adjoin the costal part of the diaphragm and the anterior abdominal wall corresponding to the epigastrium. The left part of the greater curvature is related to the visceral surface of the spleen; the other parts, stretching to the right, are in relation with the transverse colon.

If the stomach is horn-shaped and its position is more horizontal, the greater curvature lies on a level with a line connecting the ends of the tenth ribs or on a level with the umbilicus.

The **age features** of the shape and position of the stomach are as follows: the convexity of the fundus and greater curvature of the stomach of a newborn are less pronounced, while the shape of the stomach is almost cylindrical; the position is almost vertical, the capacity reaches 150 cm^3 but increases very rapidly in the first days of life. The stomach of infants is pear-shaped and situated at a higher level because it is usually displaced by the inflated intestinal loops. Later the stomach gradually takes a more horizontal position. The stomach of infants is almost completely covered by the liver.

Innervation: the left gastric (coeliac) plexus *(plexus gastrici*, s. *celiacus)*.

Blood supply: the right and left gastric arteries (*arteriae gastricae dextra* et *sinistra*) pass to the lesser curvature; the right and left gastro-epiploic arteries (*arteriae gastroepiploicae dextra* et *sinistra*) approach the greater curvature; the fundus is supplied by the short gastric arteries *(arteriae gastricae breves)* from the splenic artery *(arteria lienalis)*.

The lymph is drained from the walls of the stomach into the regional lymph nodes situated on the lesser and greater curvatures.

THE SMALL INTESTINE

The **small intestine** *(intestinum tenue)* (Figs 445–449, 475) is that part of the digestive tract which commences at the pylorus of the stomach and ends by the ileocolic orifice at the junction between the small and large intestine.

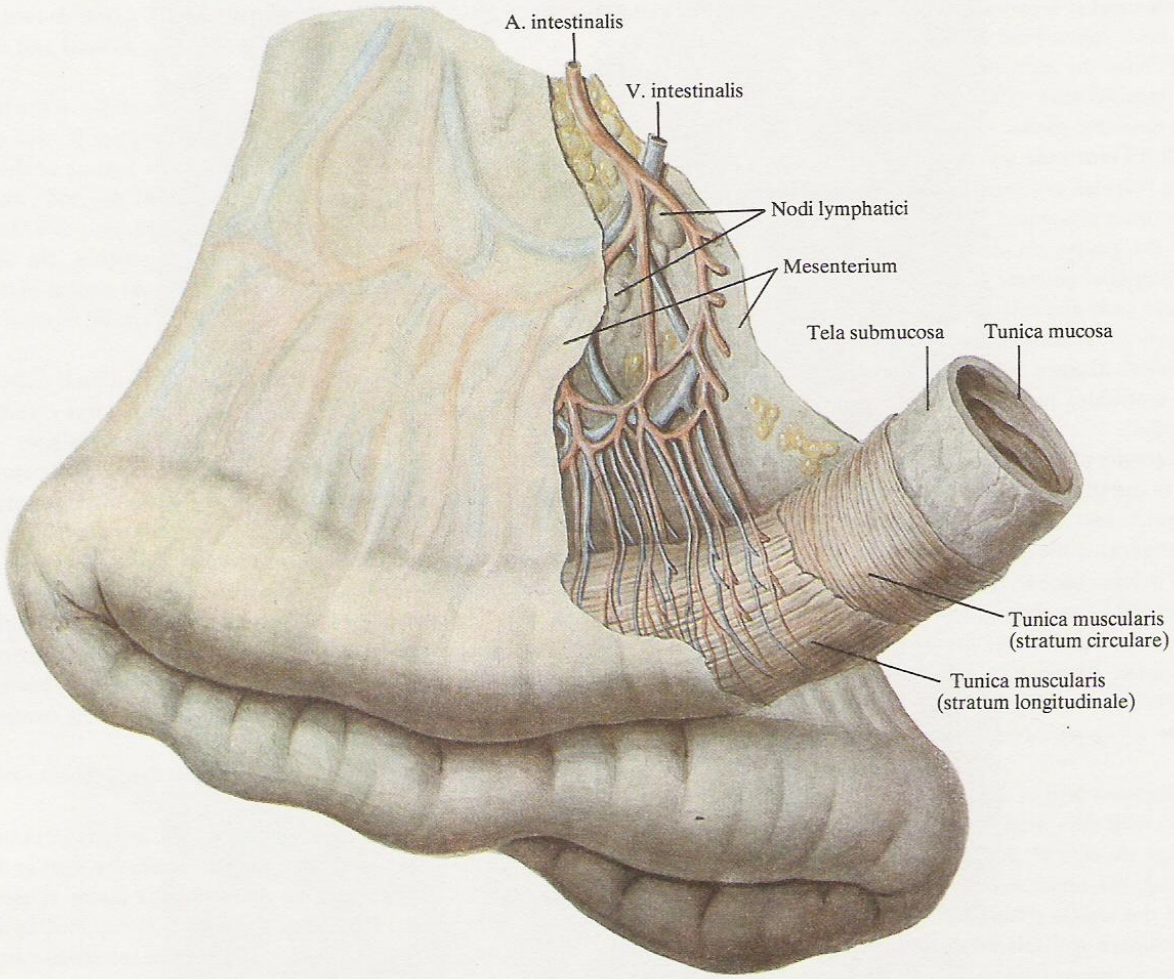
The small intestine is made up of three parts: the duodenum, the jejunum, and the ileum. The two last-named constitute its mesenteric part (mesenterial intestine).

The small intestine is the longest (up to 5 m) portion of the digestive tract; its mesenteric part occupies almost the whole lower storey of the abdominal cavity and partly the cavity of the true pelvis. Its diameter is irregular, measuring 4–6 cm in the proximal and 2.5–3.0 cm in the distal segment.

The duodenum is characteristically almost entirely retroperitoneal while the mesenterial intestine is intraperitoneal and has a mesentery *(mesenterium)*.

THE DUODENUM

The **duodenum** (Figs 446, 471–473, 476) begins under the liver at the level of the body of the twelfth thoracic or first lumbar vertebra, to the right of the vertebral column. It stretches from the pylorus of the stomach from left to right and to the back, then curves downwards and descends in front of the right kidney to the level of the second or upper part of the third lumbar vertebra; here



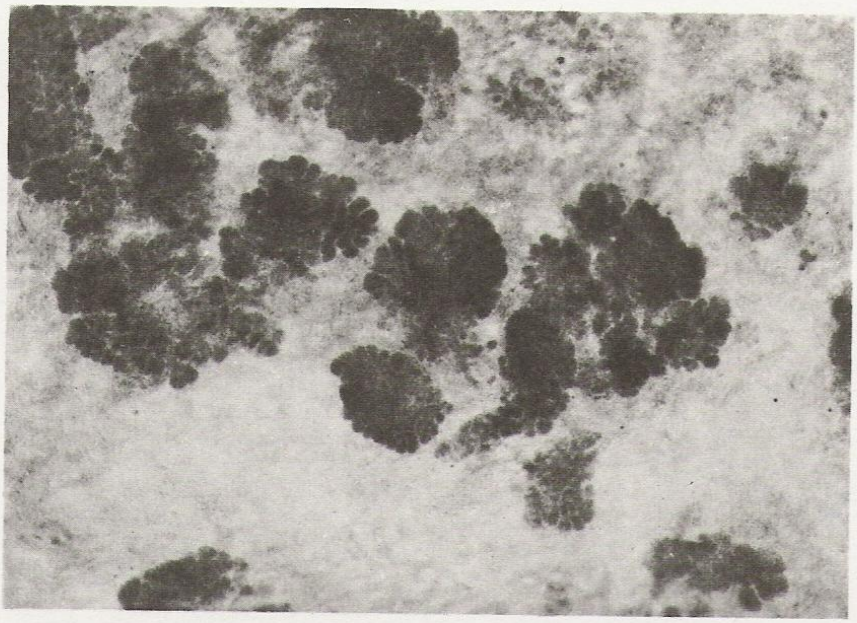
445. *Small intestine (intestinum tenue)* ($^1/_2$).
(Loop of mesenteric part of small intestine.)

it turns to the left and at first passes almost horizontally crossing the inferior vena cava in front, then ascends obliquely in front of the abdominal aorta and, finally, it is continuous with the jejunum at the level and to the left of the first or second lumbar vertebra. Thus, the duodenum forms as if a horseshoe or an incomplete ring embracing the head and partly the body of the pancreas superiorly, on the right side, and inferiorly.

Its beginning is called the **first part of the duodenum** *(pars superior duodeni)*, next come the **second part of the duodenum** *(pars descendens duodeni)*, and the **third part of the duodenum** *(pars horizontalis [inferior] duodeni)* continuous with the **fourth part of the duodenum** *(pars ascendens duodeni)*. The **superior flexure of the duodenum** *(flexura duodeni superior)* forms at the junction of the first and second parts; the **inferior flexure of the duodenum** *(flexura duodeni inferior)* forms where the second part is continuous with the third part; a sharper **duodenojejunal flexure** *(flexura duodenojejunalis)* forms at the junction between the duodenum and the jejunum.

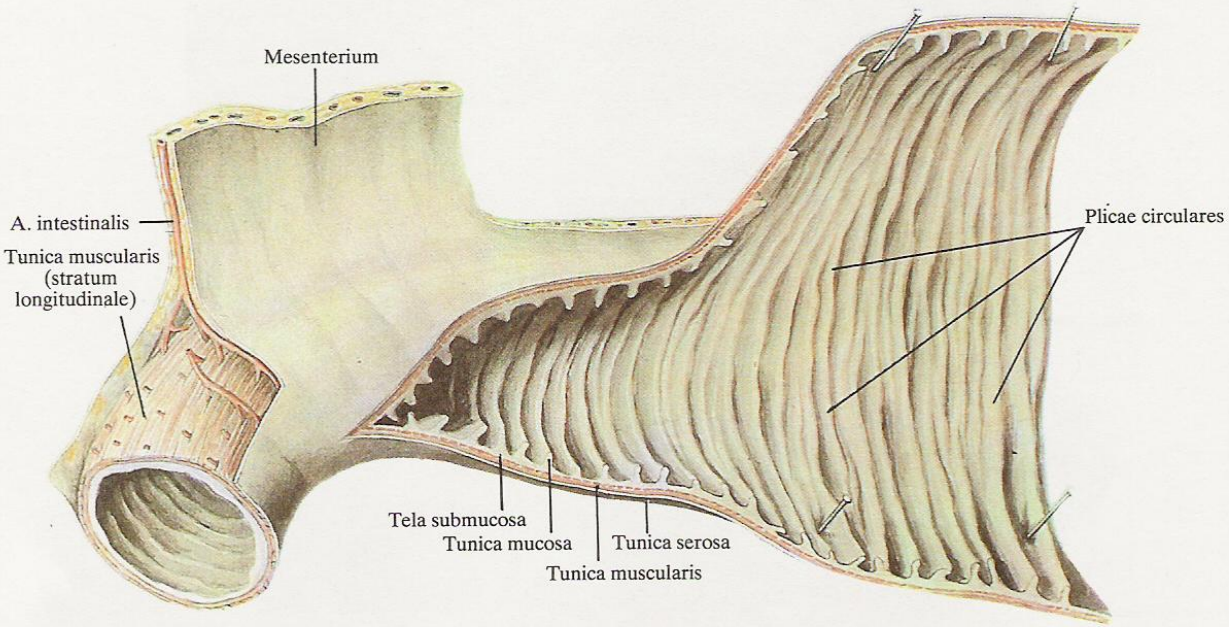
The duodenum is 27–30 cm long. Its diameter is biggest in the second part where it measures 4.7 cm. The first part adjoining the pylorus is dilated and because of the shape of its X-ray image is known as the duodenal bulb. The duodenum is slightly constricted in the middle of the second part, where the right colic artery crosses it, and at the junction of the third and fourth parts, where it is crossed by the descending superior mesenteric vessels.

The wall of the duodenum consists of three coats: serous, muscular, and mucous. Only the initial portion of the first part (for a length of 2.5–5.0 cm) is covered by the peritoneum on three sides and is, therefore, mesoperitoneal; the walls of the second and third



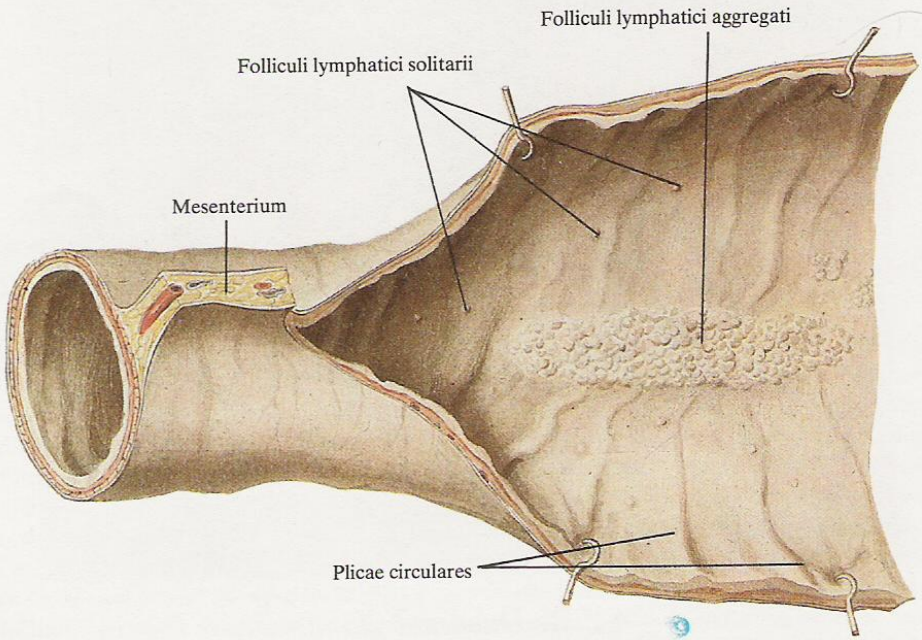
446A. *Duodenal glands* (specimen prepared by L. Lomakina).
(Photomicrograph.)
(Group of glands from totally stained duodenal wall.)

446B. *Duodenal gland.*
(Photomicrograph.)
(Gland isolated from totally stained duodenal wall.)



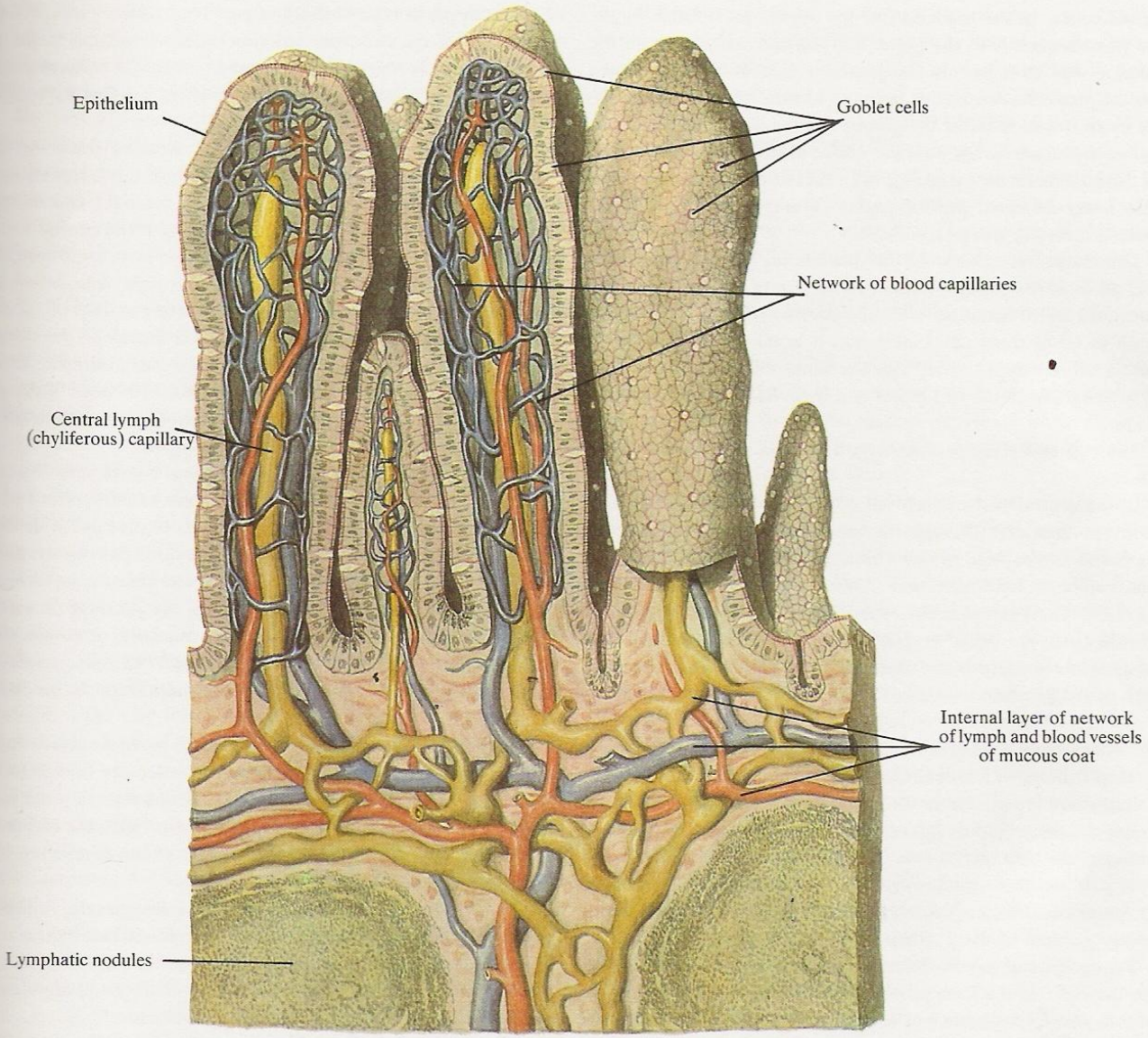
447. *Mucous coat of small intestine* ($^1/_1$).

(Segment of the jejunum, opened for a greater part of its length; the serous coat is partly removed; the longitudinal layer of the muscular coat can be seen.)



448. *Mucous coat of small intestine* ($^1/_1$).

(Segment of the ileum partly opened along the mesenteric border.)



449. *Villi of ileum* (represented schematically).

(Arterial vessels are coloured red, venous—blue; lymph vessels are yellow.)

parts, which are situated retroperitoneally, have three coats only in the areas which are covered by the peritoneum, whereas in the other regions they are composed of two coats, mucous and muscular, which are covered by the adventitia.

The **muscular coat of the duodenum** *(tunica muscularis duodeni)* is 0.3–0.5 mm thick and is thicker than that in the other part of the small intestine. It is made up of two layers of smooth muscles: an outer longitudinal and an inner circular layer.

The **mucous coat, or membrane, of the duodenum** *(tunica mucosa duodeni)* is composed of an epithelial layer with an underlying connective-tissue lamina muscularis mucosae and a layer of submucous areolar tissue separating the mucous coat from the muscular. The mucous membrane forms **longitudinal folds** *(plicae longitudinales)* in the first part of the duodenum and **circular folds** *(plicae circulares)* in the second and third parts. The circular folds are always present and occupy one half or two thirds of the duodenal

circumference. In the lower half of the second part of the duodenum (less frequently in the upper half) on the medial area of the posterior wall stretches the **longitudinal fold of the duodenum** *(plica longitudinalis duodeni)*; it is up to 11 mm long and ends distally by an elevation called the **greater duodenal papilla** *(papilla duodeni major)* on whose apex are the orifice of the common bile duct and the pancreatic duct (see Fig. 472). A little above it on the apex of the **lesser duodenal papilla** *(papilla duodeni minor)* opens an inconstant accessory pancreatic duct.

The mucous membrane of the duodenum, just like that of the other parts of the small intestine, forms on its surface finger-like projections called **intestinal villi** *(villi intestinales)* (Fig. 449). There are up to 40 of them per 1 mm^2, which lends the mucous membrane a velvety appearance. The duodenal villi are foliate, their height ranges from 0.5 to 1.5 mm and their thickness, from 0.2 to 0.5 mm.

The villi in the jejunum are cylindrical; those in the ileum are club-like.

In the central part of each villus is a lymphatic lacteal vessel. Blood vessels stretch through the entire thickness of the mucous membrane to the base of the villus, penetrate it, branch out to form capillary networks, and reach the apex of the villus (Fig. 449). The mucous membrane forms pits around the base of the villi; these are called crypts and the orifices of the **intestinal glands** *(glandulae intestinales)* open on them. The glands have the shape of straight tubules whose floor reaches the lamina muscularis mucosae. The mucous membrane of the duodenum, the villi, and of the crypts is lined with simple prismatic or cylindrical bordered epithelium with an admixture of goblet cells; cells of glandular epithelium are present in the deepest part of a crypt. Branching tubular **duodenal glands** *(glandulae duodenales)* (Fig. 446) are embedded in the submucous coat of the duodenum, most are in the upper part and their number reduces towards the lower part. Solitary lymphatic follicles *(folliculi lymphatici solitarii)* are found along the mucous coat of the duodenum.

Topography of the duodenum. The first part of the duodenum is to the right of the body of the first lumbar or twelfth thoracic vertebra and for a distance of several centimetres it lies intraperitoneally and is therefore relatively mobile. The hepatoduodenal ligament *(ligamentum hepatoduodenale)* passes from its upper border.

The upper border of the first part is in relation with the quadrate lobe of the liver, the anterior surface is related to the gall bladder which is sometimes connected to it by the peritoneal cysticoduodenal ligament. The inferior border of the first part adjoins the head of the pancreas.

The second part of the duodenum is situated along the right border of the bodies of the first, second, and third lumbar vertebrae. It is covered by the peritoneum on the right and in front. Posteriorly, the second part is in relation with the medial area of the right kidney and, to the left, with the inferior vena cava. The root of the transverse mesocolon with the right colic artery embedded in it crosses the middle of the anterior surface of the duodenum. Above this site, the right (hepatic) flexure of the colon is related to the anterior surface of the second part of the duodenum.

At the medial border of the second part is the head of the pancreas along whose border passes the superior pancreaticoduodenal artery which gives off branches to both organs.

The third part of the duodenum is on a level with the third lumbar vertebra which it crosses from right to left in front of the inferior vena cava. The fourth part ascends to the level of the body of the first (second) lumbar vertebra. The third part is retroperitoneal; the peritoneum covers its anterior and inferior surfaces and only the junction of the duodenum with the jejunum (flexure) is intraperitoneal. The peritoneal **superior duodenal** or **duodenojejunal fold** (*plica duodenalis superior* s. *plica duodenojejunalis*) passes here to the antimesenteric border of the duodenum from the base of the transverse mesocolon (see Fig. 476).

At the junction of the third and fourth parts the duodenum is crossed almost vertically by the superior mesenteric vessels (artery and vein), and on the left, by the root of the mesentery *(radix mesenterii)*. Posteriorly, the fourth part is in relation with the abdominal aorta. The upper border of the third part of the duodenum is related to the head and body of the pancreas.

The duodenojejunal flexure *(flexura duodenojejunalis)* is fixed in position by the **suspensory muscle of the duodenum** *(musculus suspensorius duodeni)* and a ligament. The muscle consists of smooth muscle fibres; it arises from the left crus of the diaphragm and is inserted into the muscular coat of the duodenum.

The age features of the duodenum: in children it is situated on a higher level and its shape is more ring-like.

THE MESENTERIAL INTESTINE

The mesenteric part of the small intestine, called the mesenterial intestine (Figs 445, 475) is in the lower storey of the abdominal cavity, i.e. below the level of the transverse line connecting the ends of the tenth ribs, under the transverse mesocolon. It commences at the duodenojejunal flexure to the left of the first (second) lumbar vertebra and ends in the iliac fossa on a level with the body of the fourth lumbar vertebra, at the ileocaecal junction. The mesenterial intestine reaches 5 m in length and its diameter measures 4.8 cm in the initial portion and 2.7 cm in the distal portion. It is intraperitoneal, i.e. completely covered by the visceral peritoneum, except for a narrow strip at the attachment of the mesentery. The mesentery arises on the posterior wall of the abdominal cavity and is a fold (duplicature) of the peritoneum. Its free border surrounds the small intestine as if suspending it, while on the posterior wall it is continuous with the parietal peritoneum. The site of origin of the mesentery from the posterior abdominal wall is an oblique line stretching downwards from left to right, from the root of the transverse mesocolon to the ileocaecal junction. This line is the root of the mesentery *(radix mesenterii)* running from the second lumbar vertebra on the left to the sacro-iliac joint on the right.

The blood and lymph vessels and the nerves of the small intestine enter the root of the mesentery to pass between its layers. The regional mesenteric lymph glands *(nodi lymphatici mesenterici)* are also lodged in the duplicature between the peritoneal layers.

The root of the mesentery is 15–20 cm long, while the free border is about 5 m long as a result of which the small intestine forms very many (up to 16) coils, or loops (see Fig. 475). The width of the mesentery is least at the beginning and end of the mesenteric part of the small intestine and greatest in its central portions. This determines the degree of mobility and displacement of the intestinal loops.

According to some signs (see below), two portions are distinguished in the mesenterial intestine: the proximal two thirds of its length form the jejunum, the distal one third, the ileum. There is no distinct borderline between them. The extreme distal part of the ileum is in turn distinguished as the terminal ileum *(ileum terminale)*.

The loops of the small intestine are marked by a more or less definite position and direction: six or seven loops of the proximal portion (jejunum) of the intestine lie horizontally occupying the left upper part of the lower storey of the abdominal cavity and the umbilical region; seven or eight loops of the distal portion (ileum) have a vertical position and are in the hypogastrium, right iliac region, and the cavity of the true pelvis. The last loops of the ileum, proximal to the terminal part, lie in the true pelvis as the result of which the terminal part is directed upwards and to the right (ascends) into the iliac fossa. Besides, the intestinal loops lie in two layers: some of them (one third) are close to the surface, the others (two thirds) occupy a deeper position.

Two borders are distinguished in the mesenterial intestine: the mesenteric border by means of which it is attached to the mesentery and an opposite, free (antimesenteric) border. Vessels and nerves approach the intestinal wall in the region of the mesenteric border.

The walls of the mesenterial intestine are composed of three coats: serous, muscular, and mucous.

The **serous coat of the small intestine** *(tunica serosa intestini tenuis)* invests the intestine on all sides except for a narrow strip on the mesenteric border where both layers of the peritoneum separate on approaching the intestinal wall.

The serous coat is connected to the underlying tissue of the muscular coat by an areolar **subserous coat** *(tela subserosa)*.

The **muscular coat of the small intestine** *(tunica muscularis intestini tenuis)* consists of two layers of smooth muscle fibres; an outer **longitudinal layer** *(stratum longitudinale)* and an inner **circular layer** *(stratum circulare)*.

The **mucous coat, or membrane, of the small intestine** *(tunica mucosa intestini tenuis)* is formed of an epithelial covering with underlying lamina muscularis mucosae and a submucous coat (tela submucosa). The mucous membrane forms **circular folds** *(plicae circulares)* (Fig. 447), bears **intestinal villi** *(villi intestinales)*, and has crypts with openings of the **intestinal glands** *(glandulae intestinales)*, and **lymphatic follicles** *(folliculi lymphatici)*, i.e. it has all the elements which (except for the duodenal glands) are described above in the mucous coat of the duodenum. The mucous coat of the mesenterial intestine differs in structure from that of the duodenum in that it has less circular folds, which gradually reduce in number from the jejunum to the ileum and almost completely disappear in the terminal ileum. The total number of folds in the small intestine ranges from 500 to 1200. Their height also gradually diminishes from the beginning to the end of the small intestine.

The villi in the mesenterial intestine are thinner and a little shorter than those in the duodenum. The number of villi also reduces from the beginning to the end of the small intestine: there are 30 to 40 per 1 mm^2 of them in the jejunum and 18 to 30 per 1 mm^2 in the ileum; the length and thickness of the villi also diminish.

At the junction of the ileum and the caecum the **ileocolic orifice** *(ostium ileocaecale)*, by means of which they communicate, is surrounded by a valve of the mucous membrane of the ileum. The valve is funnel-shaped and projects into the caecum; it is called the **ileocolic valve** *(valva ileocaecalis)*.

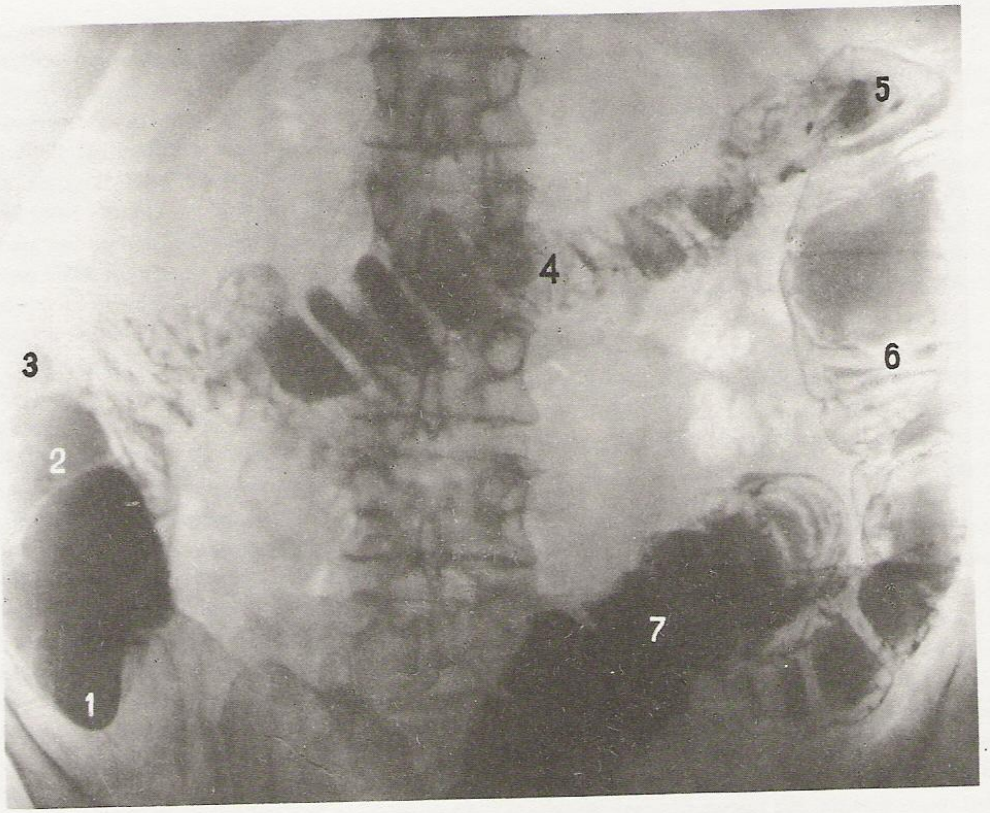
The **submucous coat** *(tela submucosa)* of the mesenterial intestine contains **solitary lymphatic nodules** *(folliculi lymphatici solitarii)* which reach the surface of the mucous coat; these follicles are the size of a millet and their number comes to 200. Besides, in this part of the small intestine, on the antimesenteric border, are found **aggregated lymphatic nodules** *(folliculi lymphatici aggregati)* (Fig. 448). The aggregates are 2–10 cm long, 1–3 cm wide, and their number in the small intestine ranges from 30 to 40.

Topography of the mesenterial intestine. The mesenterial intestine occupies the central part of the lower storey of the abdominal cavity below the transverse mesocolon. The small intestine is bounded by the ascending (on the right), transverse (above), and descending (on the left) colon. Anteriorly the intestinal loops are covered by the greater omentum (as if by an apron) descending from the greater curvature of the stomach and the inferior border of the transverse colon and separating the loops from the anterior abdominal wall. Posteriorly, the intestinal loops are in relation with the parietal peritoneum covering to the right of the root of the mesentery the third part of the duodenum, the head of the pancreas, the lower end of the right kidney, the right ureter, the right psoas major muscle; to the left of the root the parietal peritoneum covers the lower end of the left kidney, the left ureter, the left psoas major muscle, the abdominal aorta, the inferior vena cava, and the common iliac vessels. On the left and inferiorly the intestinal loops are related to the pelvic colon and its mesentery.

In the cavity of the true pelvis the intestinal loops are in relation with the urinary bladder anteriorly, the rectum posteriorly (with the uterus and its appendages in females).

The terminal ileum crosses the right psoas major muscle and the right common iliac vessels.

The **age features** of the mesenterial intestine: the initial part is located higher in children, sometimes on a level with the first lumbar vertebra; the terminal part (ileocaecal junction) is found high under the liver in the newborn but descends with age and may even be in the cavity of the true pelvis at old age. The relative



450. *Large intestine* (radiograph).

(Contrast medium completely fills the caecum and partly other parts of the large intestine.)

1—caecum
2—ascending colon
3—right flexure of colon
4—transverse colon
5—left flexure of colon
6—descending colon
7—pelvic colon

length of the intestine reduces with age: it is seven times the length of the body in the newborn and three-four times the length of the body in an adult.

The omentum covers the intestinal loops only partly in children under 7 years and completely by the age of 7.

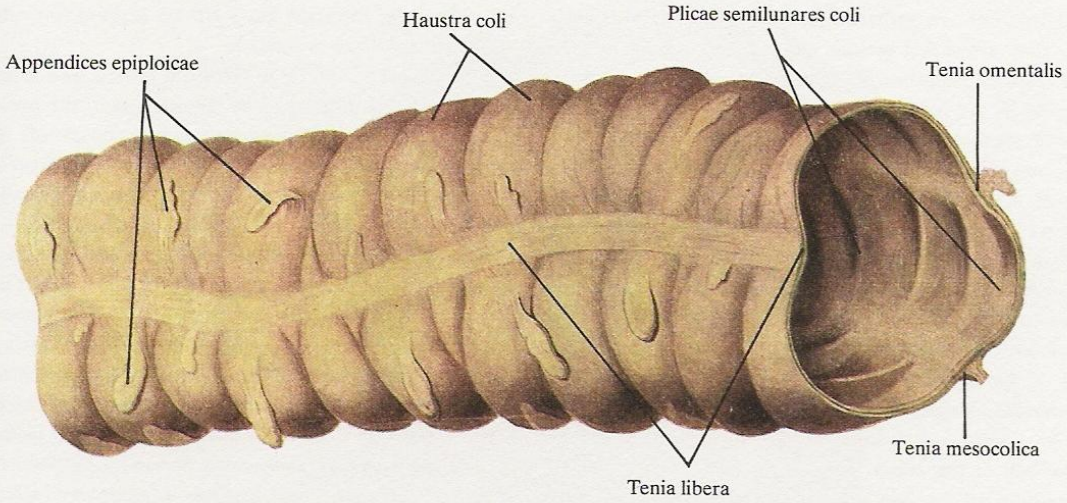
Innervation: the duodenum—the coeliac plexus *(plexus celiacus)*, hepatic plexus *(plexus hepaticus)*, superior mesenteric plexus *(plexus mesentericus superior)*; the mesenterial intestine—the coeliac plexus *(plexus celiacus)*, superior mesenteric plexus *(plexus mesentericus superior)*.

Blood supply: the duodenum—the hepatic and superior mesenteric arteries (*arteriae hepatica communis* et *mesenterica superior*); the mesenterial intestine—superior mesenteric artery *(arteria mesenterica superior)*.

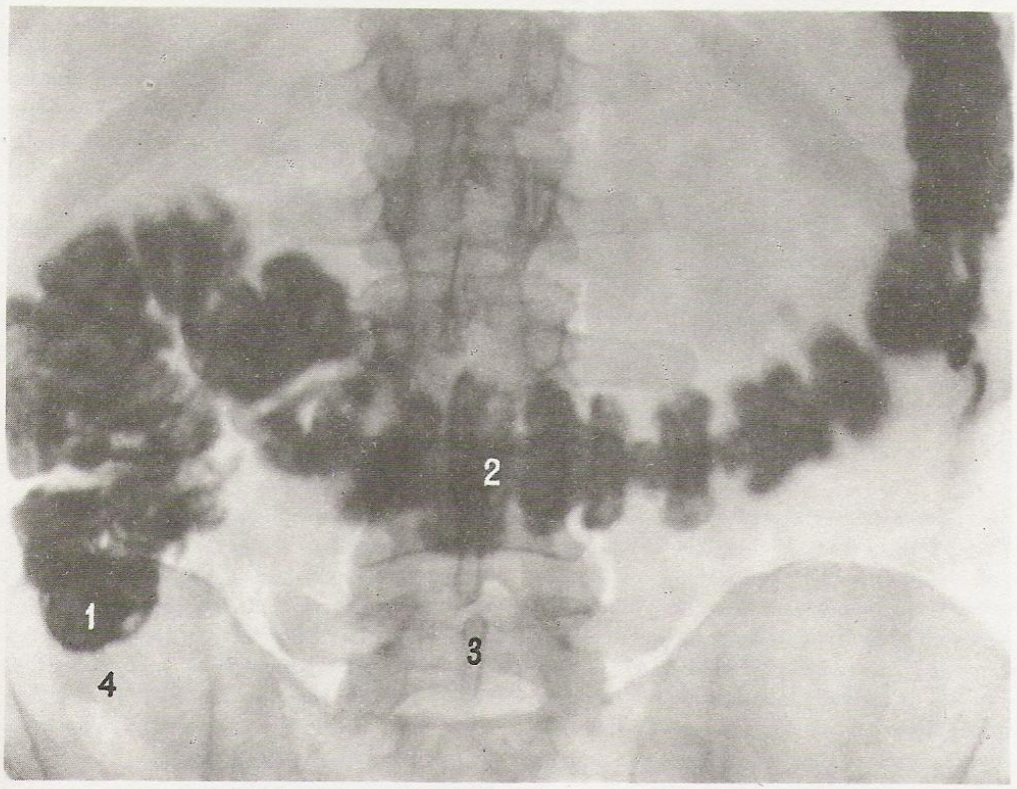
THE LARGE INTESTINE

The **large intestine** *(intestinum crassum)* (Figs 450-458, 475, 476) is the distal part of the digestive tract; it begins from the end of the small intestine at the ileocolic valve and terminates as the anus. It consists of three parts: the caecum, the colon, and the rectum. The colon in turn is separated into four parts: the ascending colon, the transverse colon, the descending colon, and the pelvic colon. The total length of the large intestine varies from 100 to 150 cm. Its calibre is 7-8 cm in the initial part (caecum) and 4-5 cm in the terminal part (the distal segment of the descending colon). The large intestine differs from the small intestine in position, shape, and structure.

The principal distinguishing signs of the large intestine are its larger calibre (4-5 cm) and the special arrangement of the muscular layers—the presence of muscular bands (taeniae coli), sacculations, and projections called appendices epiploicae. The longitudinal muscle fibres of the large intestine (except for the vermiform



451. *Large intestine (intestinum crassum)* ($^2/_3$).
(Segment of the transverse colon.)



452. *Large intestine* (radiograph).

1—caecum
2—transverse colon
3—fifth lumbar vertebra
4—ileum

appendix and rectum) do not form a continuous layer, like that of the small intestine, but are gathered in three longitudinal bands 3–4 mm wide. They are called **taeniae coli** and are arranged at an equal distance from one another. **Taenia libera, taenia mesocolica,** and **taenia omentalis** are distinguished. Their position on the caecum and the different parts of the colon is described below.

On the caecum the three taeniae converge to meet at the base of the vermiform appendix and surround it as a continuous muscular layer. In a like manner they become wider as they reach the rectum and form a longitudinal muscular layer.

In the space between the taeniae the wall of the large intestine forms a succession of **sacculations of the colon** *(haustrae coli)* which are separated from one another by transverse grooves projecting into the cavity of the intestine as the **semilunar folds of the colon** *(plicae semilunares coli)*. Masses of fat enclosed in folds of the peritoneum, which are called **appendices epiploicae,** project from the grooves on the wall of the colon. They form two rows on the ascending, descending, and pelvic colon, one row on the transverse colon, and are absent on the caecum. In some cases adjacent appendices of one row fuse to form a single fold.

The large intestine differs from the small intestine also in colour: the large intestine has a greyish (ashen) tint, while the wall of the small intestine is pinkish.

Each part of the large intestine has its own characteristic features and is distinguished by its relation to the peritoneum.

The caecum is intraperitoneal, it is completely invested by the peritoneum and is devoid of the mesentery. Developmental variants are often encountered, with the caecum (together with the ascending colon and the terminal ileum) attached to a common ileocaecal mesentery. The ascending colon is covered by the peritoneum on its anterior and lateral surfaces but not on the posterior surface, i.e. it is mesoperitoneal. The transverse colon is completely covered by the peritoneum, i.e. it is intraperitoneal and has a mesentery called the transverse mesocolon *(mesocolon transversum)*. The descending colon, like the ascending colon, is mesoperitoneal. The pelvic colon is intraperitoneal and possesses a mesentery called the pelvic mesocolon *(mesocolon sigmoideum)*. The rectum is at first intraperitoneal and has a mesentery called the mesorectum, more distally it is mesoperitoneal, and its terminal (perineal) part is extraperitoneal.

THE CAECUM

The **caecum** (Figs 452–454, 476, 477) is the beginning of the large intestine. It has the shape of a blind pouch and is situated below the junction of the ileum with the large intestine (by analogy with the fundus of the stomach which is to the left of and above the cardiac portion). Its length varies in different individuals from 3 to 8 cm, its width ranges between 4 and 7 cm and it is the widest part of the large intestine (except for the ampulla of the rectum).

The caecum is usually completely covered by the peritoneum and is thus intraperitoneal, but may be mesoperitoneal in some cases, i.e. covered on three surfaces.

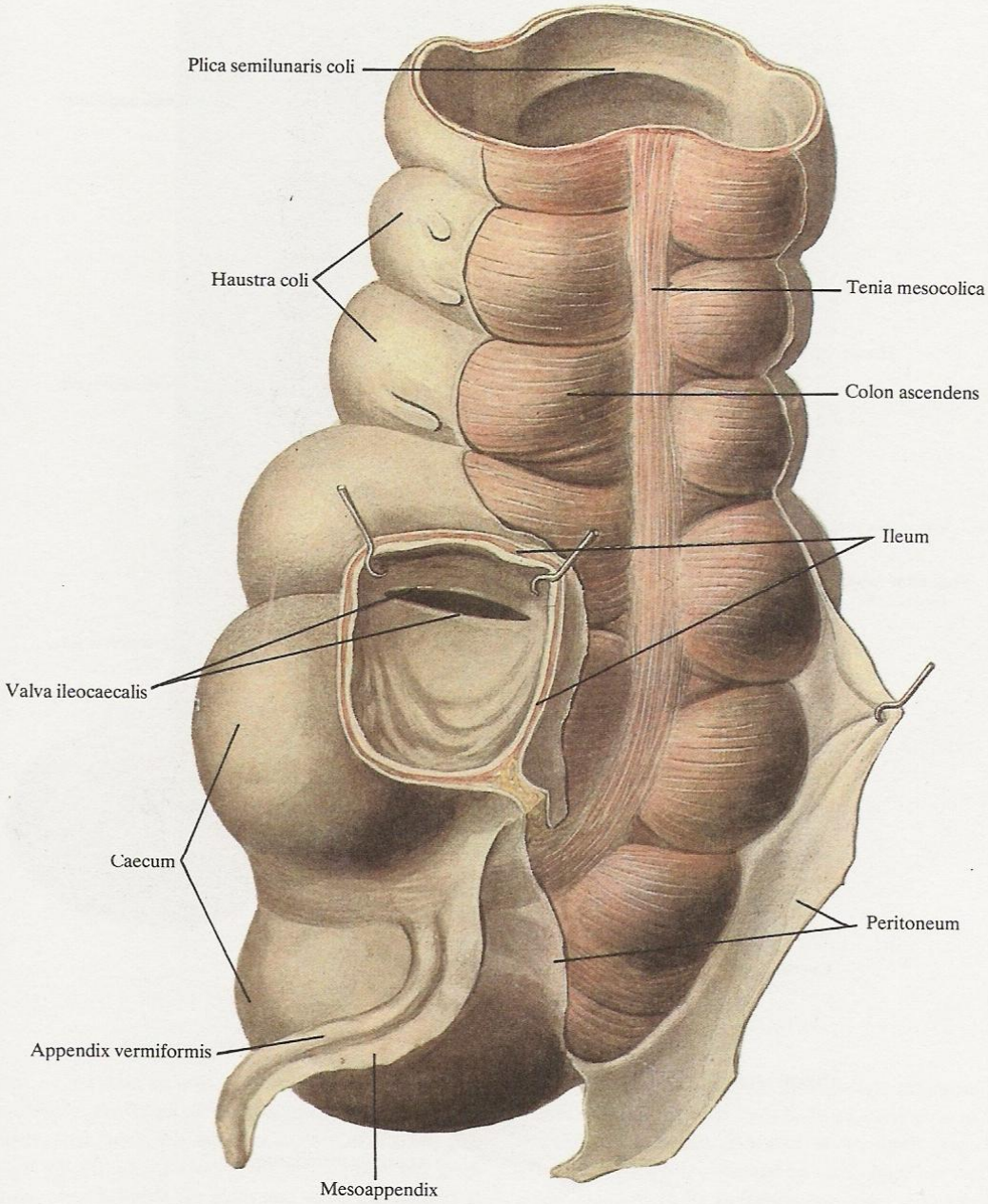
The **vermiform appendix** *(appendix vermiformis)* (Figs 453, 454) arises from the posteromedial wall of the caecum 0.5–5 cm below the ileocaecal junction. It is a narrow tube 3–4 mm in diameter and 2.5–15 cm in length. Its lumen communicates with the lumen of the caecum. The appendix has its own mesentery called the mesoappendix which connects it with the wall of the caecum and the terminal part of the ileum.

The appendix is usually located in the right iliac fossa; its free end is directed downwards and medially, reaches the arcuate line of the pelvis *(linea terminalis)*, and sometimes descends into the true pelvis. This position, however, varies in different individuals: the appendix, for instance, may be behind the caecum to which it is attached by the peritoneum covering it or it may be even extraperitoneal when the caecum is mesoperitoneal.

THE COLON

The position of the **colon** (Figs 475, 476) in the cavity of the abdomen is such that it borders the coils of the small intestine lying in the middle of the lower storey. The ascending colon is on the right, the transverse colon is above, the descending colon is on the left, and the pelvic colon is on the left and partly below.

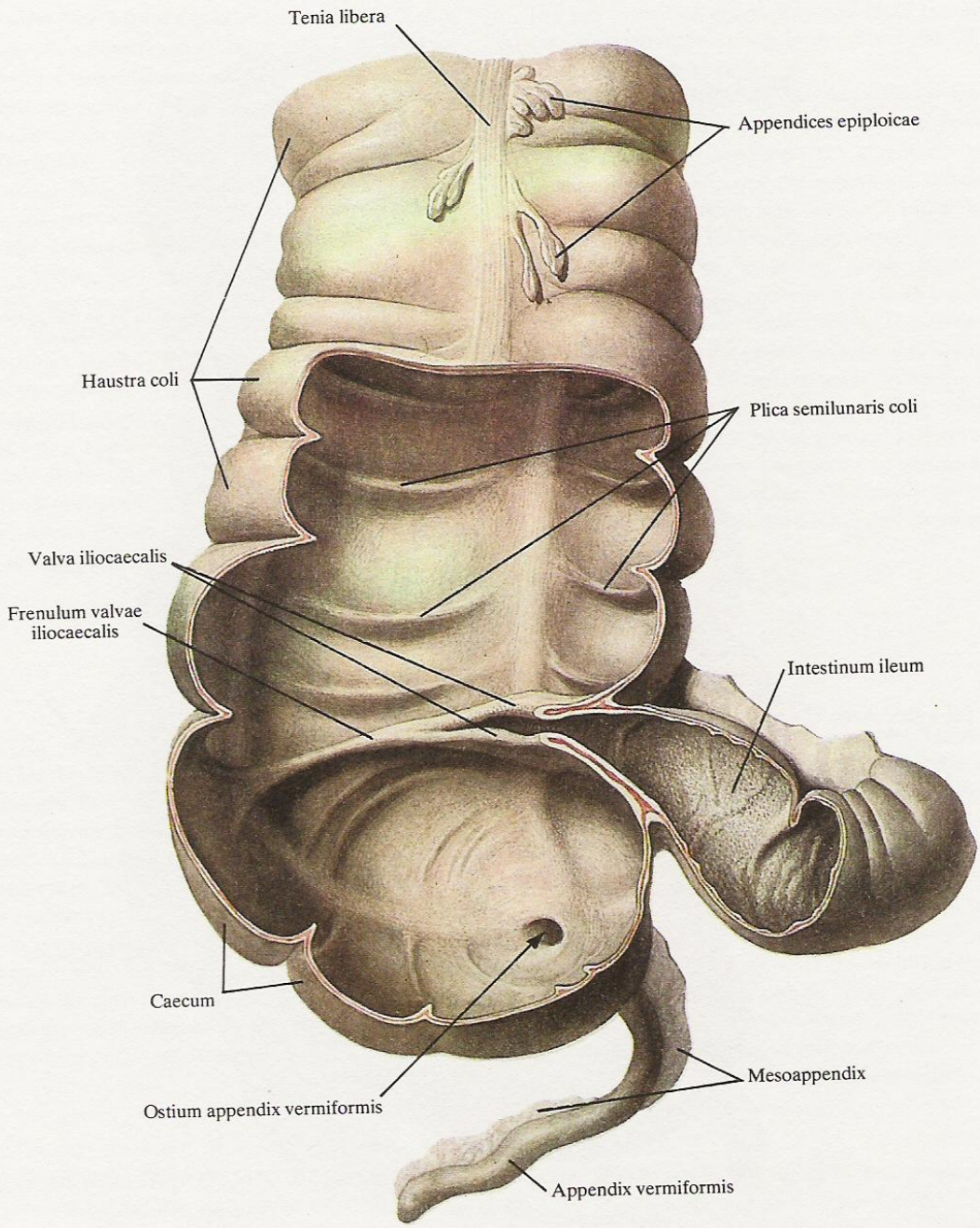
The **ascending colon** *(colon ascendens)* (Figs 475, 476) begins where the ileum empties into the large intestine and is a continuation of the caecum. It is separated from the caecum by two grooves which correspond to the frenula of the ileocolic valve (see *Structure of the walls of the caecum and colon*). The posterior surface of the ascending colon, which is devoid of peritoneum, lies on the posterior abdominal wall occupying an extreme lateral area on the right. The ascending colon commences slightly below the level of the iliac crest, stretches vertically upwards, first in front of the quadratus lumborum muscle and then in front of the right kidney, and reaches the inferior surface of the right lobe of the liver; here it bends to the left and ventrally (forwards) to be continuous with the transverse colon; the bend is called the **right flexure of the colon** *(flexura coli dextra)*. It usually slopes more than the left flexure (see below) and is directed both in the frontal and sagittal planes, as a result of which the first part of the transverse colon lies closer to the surface than the ascending colon and in front of it (the same applies to the left flexure). The ascending colon is up to 20 cm long, but its position and length are quite variable: when the caecum occupies a high position the length of the ascending colon may be 12 cm and even less. The taenia coli are arranged on the



453. *Caecum and vermiform appendix;* posterior aspect ($^1/_1$).
(The caecum and a segment of the ascending colon.)

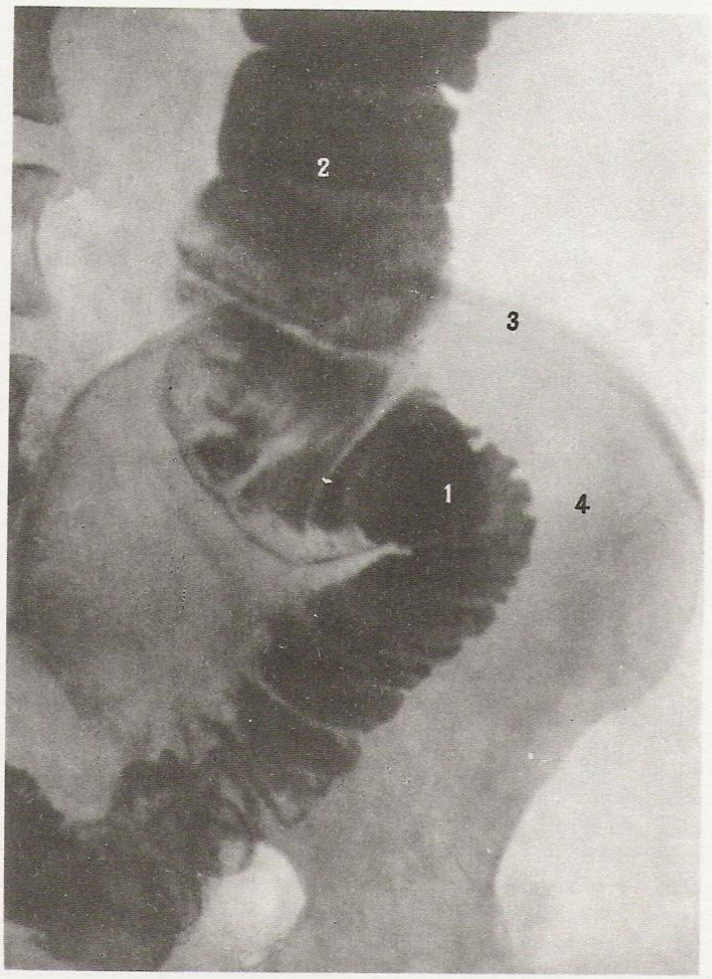
ascending colon as follows: taenia libera is on the anterior surface, taenia omentalis is on the posterolateral surface (extraperitoneal), taenia mesocolica is on the posteromedial surface.

The **transverse colon** *(colon transversum)* (Figs 474–476) begins in the right hypochondric region on the level of the tenth costal cartilage from the right flexure of the colon. It passes obliquely from right to left and upwards into the left hypochondric region, where on the level of the ninth costal cartilage or eighth intercostal space it terminates at the **left flexure of the colon** *(flexura coli sinistra)* to be continuous with the descending colon. Just like on the



454. *Caecum, vermiform appendix, and ascending colon;* anterior aspect ($^1/_1$).
(Part of the wall is removed.)

right, the left segment of the transverse colon lies closer to the surface (more ventrally) than the descending colon; as a result the transverse colon on the whole lies ventral of the ascending and descending parts. The middle portion of the transverse colon sags across the epigastric region so that the ascending and descending colon together with the transverse colon resemble the letter M. The transverse colon is about 50 cm long and is the longest part of the large intestine. It has its own mesentery called the **transverse mesocolon** *(mesocolon transversum)* which arises on the posterior abdominal wall from the parietal peritoneum. The line of attachment



455. *Pelvic colon* (radiograph).

1—pelvic colon
2—descending colon
3—iliac crest
4—ala of ileum

of the mesentery, i.e. its root, crosses from right to left the second part of the duodenum, the head of the pancreas and the inferior border of its body, and partly the anterior surface of the left kidney. The mesentery is 10–15 cm wide in the middle part but gradually becomes narrower towards the sides and comes to naught at the flexures. The mesentery is attached on the intestine along the taenia mesocolica which is a continuation of the taenia mesocolica of the ascending colon. The gastrocolic ligament *(ligamentum gastrocolicum)* is attached to the anterior surface of the transverse colon along the continuation of the taenia omentalis. This peritoneal ligament arises from the greater curvature of the stomach and the upper part of the duodenum, and after attachment to the taenia omentalis of the transverse colon it continues downwards as the greater omentum *(omentum majus)* covering all the small intestine (the structure of the ligament and omentum is described below). Due to this position of the greater omentum, the transverse colon, which is covered by it in front, cannot be seen at all or only through it when the abdomen is cut open (Fig. 474); when the greater omentum is reflected upwards together with the transverse colon fastened to its posterior surface, the posterior (dorsal) surface of the transverse colon with the taenia libera and the transverse mesocolon is exposed (see Fig. 475).

The **left flexure of the colon** *(flexura coli sinistra)* lies in the left hypochondrium at a much higher level than the right flexure and dorsal to it (deeper), i.e. immediately under the inferior border of the spleen. The left end of the transverse colon meets the initial part of the descending colon at an acute angle whose apex is held fast by the phrenicocolic ligament *(ligamentum phrenicocolicum)*.

The **descending colon** *(colon descendens)* (see Fig. 476) lies on the posterior abdominal wall on the extreme left at the lateral wall.

It begins superiorly from the left (splenic) flexure and descends along the posterior abdominal wall; its posterior surface, which is devoid of peritoneum, is in front of the lateral area of the left kidney and the quadratus lumborum muscle. At the level of the left iliac crest it is continuous with the next part of the large intestine, the pelvic colon. The descending colon is further from the median plane of the abdomen than the ascending colon. It is also longer and measures up to 22.5 cm. Its calibre is lesser than the calibres of the above described parts of the large intestine and is 4 cm at the junction with the pelvic colon. The number and depth of the sacculations diminish; the arrangement of the taeniae and the appendices epiploicae is the same as on the ascending colon.

The **pelvic (sigmoid) colon** *(colon sigmoideum)* (Figs 455, 476, 477) is the mesenteric part of the large intestine which comes next after the descending colon. It lies in the left iliac fossa and begins superiorly and laterally at the level of the posterior border of the iliac crest. After forming two loops it extends medially and downwards, curves over the arcuate line of the pelvis, and enters the cavity of the true pelvis where it is continuous with the rectum on the level of the third sacral vertebra. The length of the pelvic colon is 54 cm on the average, but is marked by considerable individual variations (from 15 to 67 cm); its calibre is about 4 cm.

The pelvic colon forms two loops; one of them, the proximal one, lies on the iliacus muscle with the convexity directed downwards; the other, distal loop lies on the psoas major muscle and its convexity is directed upwards. Part of the pelvic colon is below the arcuate line in the true pelvis and is continuous with the rectum. The mesentery of the pelvic colon is called the pelvic mesocolon *(mesocolon sigmoideum)*. Its calibre measures 12 cm but is variable along the length of the intestine. The root of the mesentery crosses the floor of the iliac fossa along a line descending obliquely from left to right. The line of the root forms two angles corresponding to the two loops: a proximal angle slightly concave and an acute convex angle; a recess of the pelvic colon *(recessus intersigmoideus)* forms at the apex of the distal angle. The root of the pelvic mesocolon runs across the iliacus and psoas muscles and the left common iliac vessels and left ureter which run along the arcuate line. After bending over the arcuate line the root of the mesentery passes across the region of the left sacro-iliac joint to the anterior surface of the upper sacral vertebrae. At the level of the third sacral vertebra the pelvic mesocolon terminates at the origin of the very short mesentery of the rectum (mesorectum). The length of the root of the mesentery is greatly variable and determines the steepness and size of the loop of the pelvic colon.

Structure of the walls of the caecum and colon. Only the intraperitoneal parts of the large intestine are completely formed of three coats (serous, muscular, and mucous), namely, the caecum (not always), transverse colon, pelvic colon, and the upper part of the rectum. The ascending and descending colon and, in some cases, also the caecum are covered by the peritoneum on three surfaces: lateral, anterior, and medial.

The mesoperitoneal parts of the large intestine, namely the ascending and descending colon, have on their posterior wall an area a few (2–3) centimetres wide which is devoid of the serous coat; the mesenteric parts of the large intestine, i.e. the transverse and pelvic colon, bear on the line of attachment of the mesentery a narrow strip devoid of the peritoneum. The serous coat of the colon continues into the grooves on it.

The **muscular coat** *(tunica muscularis)* forms two layers along the whole length of the large intestine: an outer longitudinal and an inner circular layer. As it is pointed out above, the longitudinal layer is not continuous but for a considerable distance occurs in bands, or taeniae (Figs 451, 453) and is thinner than the circular layer. The vermiform appendix, on which the taeniae converge, has an uninterrupted double-layer muscular coat which, however, is less developed than that in the other parts.

The **mucous coat, or membrane** *(tunica mucosa)* is composed of epithelium with an underlying basement membrane, a connective-tissue layer, and lamina muscularis mucosae under which is the submucous coat *(tela submucosa)*.

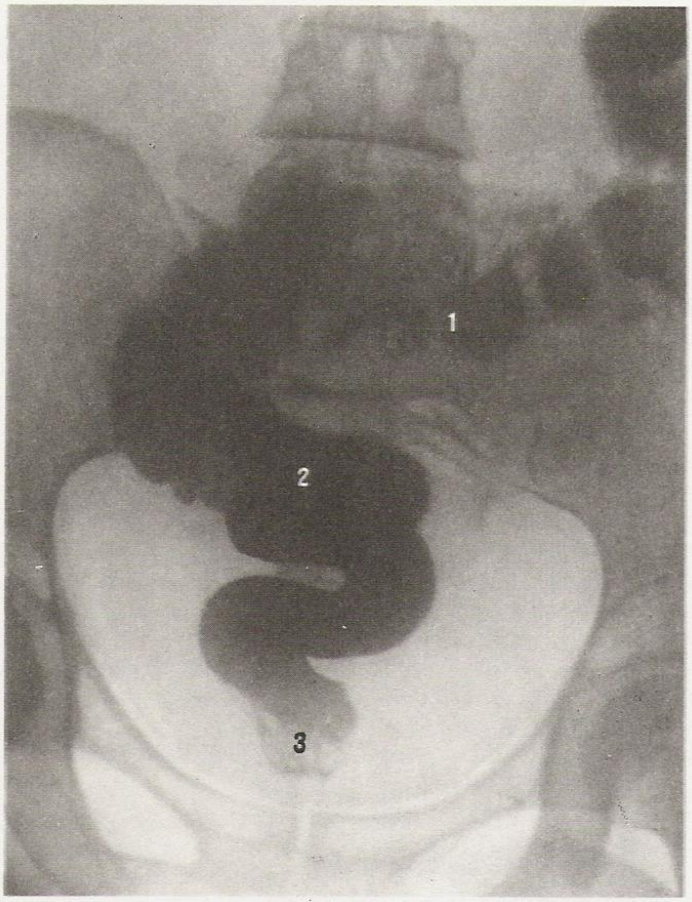
The epithelium of the mucous membrane consists of columnar cells with very many goblet cells. The mucous coat of the large intestine contains intestinal glands *(glandulae intestinales)* but has no villi. Along its whole distance there are **solitary lymphatic nodules** *(folliculi lymphatici solitarii)*. In line with the transverse grooves, the mucous membrane forms the **semilunar folds of the colon** *(plicae semilunares coli)*.

At the junction of the ileum and the large intestine, at the **ileocolic orifice** *(ostium ileocaecale)*, there are two constantly present folds of the intestinal wall mostly composed of the circular muscular layer. They form the **ileocolic valve** *(valva ileocaecalis)* (Figs 453, 454). The edges of the orifice are fused and continue as the **frenulum of the ileocolic valve** *(frenulum valvae ileocaecalis)* at the junction of the caecum and ascending colon. The circular muscular layer is developed best in the base of the valve where it forms a sort of sphincter.

Where the lumen of the vermiform appendix communicates with the caecum is the **opening of the vermiform appendix** *(ostium appendicis vermiformis)* (Fig. 454). The mucous membrane of the vermiform appendix is rich in lymphoid tissue forming an almost continuous layer of **lymphatic nodules of the vermiform appendix** *(folliculi lymphatici aggregati appendicis vermiformis)*.

THE RECTUM

The **rectum** *(rectum)* (Figs 456–458, 570) is the terminal part of the large intestine and the digestive tract in general. It is in the cavity of the true pelvis and lies on its posterior wall which is formed by the sacrum, coccyx, and the posterior part of the muscles of the pelvic floor. It begins from the end of the pelvic part of the pelvic colon at the level of the third sacral vertebra and terminates by the anus in the region of the perineum (see Figs 482, 483). Its length varies from 14 to 18 cm. Its calibre varies along its



456. *Rectum* (radiograph).

1—pelvic colon
2—dilatation of initial part of rectum
3—dilatation of terminal part of rectum

length from 4 cm (where it begins from the pelvic colon) to 7.5 cm in the middle part (ampulla) and again reduces to the size of a slit at the level of the anus.

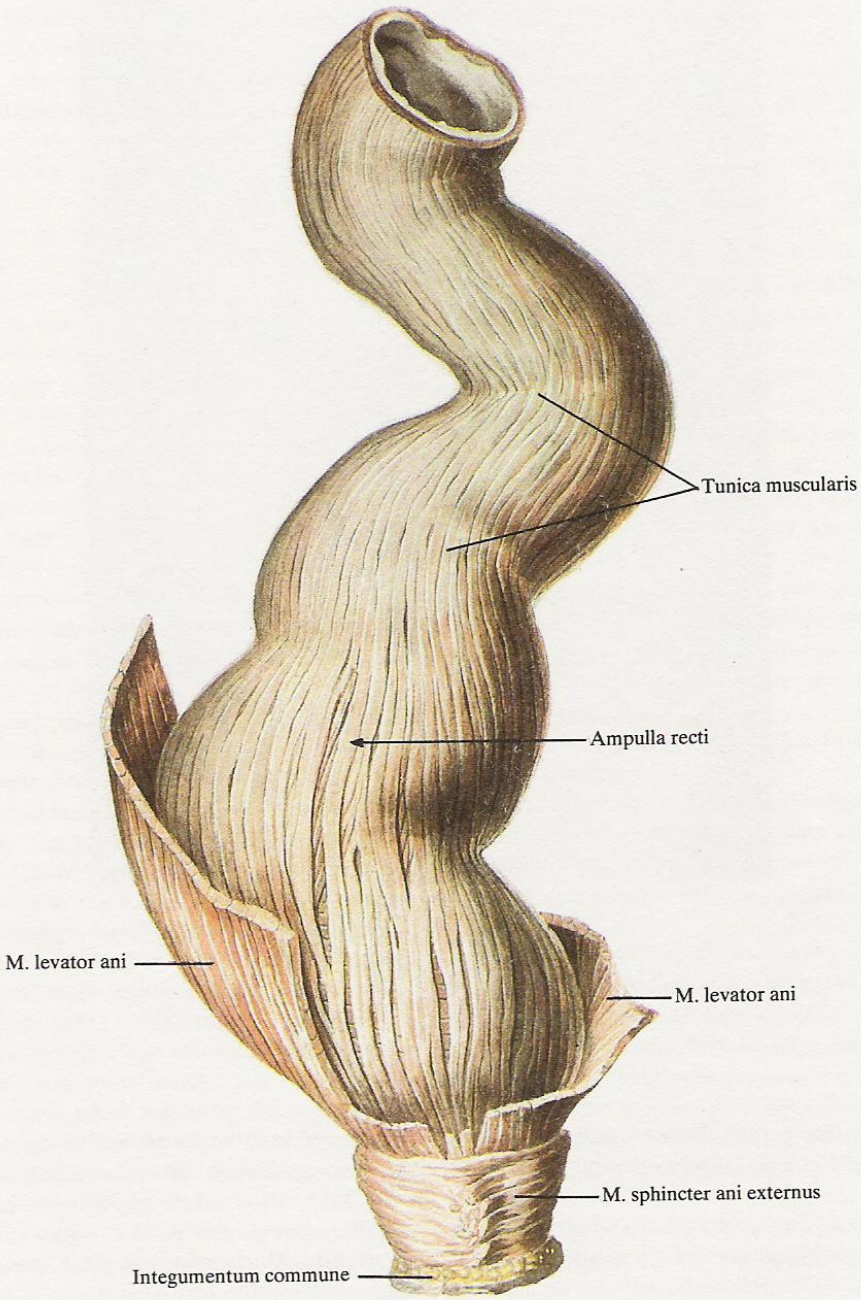
The rectum is composed of two parts: pelvic and perineal. The pelvic part is above the floor (diaphragm) of the pelvis, in the cavity of the true pelvis, and is in turn subdivided into a narrower supra-ampullar part and a wide **ampulla of the rectum** *(ampulla recti)*. The second part is under the pelvic diaphragm in the perineal region and is known as the **anal canal** *(canalis analis)*.

The pelvic part of the rectum forms a curve in the sagittal plane with the convexity directed posteriorly, corresponding to the curve of the **sacral flexure** *(flexura sacralis)*; the upper part of the curve passes from front to back and downwards, the lower part passes from back to front and downwards. There are also inconstant curves in the frontal plane, the upper part descending from left to right and the lower part passing in the opposite direction. The second curve of the rectum in the sagittal plane is convex anteriorly and is at the junction of the pelvic and perineal parts. After passing through the pelvic diaphragm the rectum bends sharply (almost at a right angle) to the back to form the **perineal flexure** *(flexura perinealis)*. The rectum as if skirts the apex of the coccyx here. The length of the pelvic part varies from 10 to 14 cm, the perineal part is 4 cm long.

The relation of the rectum to the peritoneum of the true pelvis varies at different levels (see Figs 547, 562). The pelvic part is covered by the peritoneum to a certain extent. The perineal part is devoid of the peritoneal covering. The uppermost part (supra-ampullar), beginning at the level of the third sacral vertebra, is completely enclosed in a serous coat and has a short, narrow, and thick mesentery (see Fig. 570).

Whether this part of the mesentery should be related to the rectum is an arguable question. Many anatomists relate the whole mesenteric part to the pelvic colon.

Already at the level of the inferior border of the third sacral



457. *Rectum* ($^2/_3$).

[Muscular coat *(tunica muscularis)*; longitudinal layer *(stratum longitudinale)*.]

vertebra the rectum begins losing its serous covering, at first on the posterior surface, then on the lateral surfaces, and, finally, on the anterior surface. Thus, the upper, supra-ampullar portion of the pelvic part is intraperitoneal, the upper portion of the ampulla is mesoperitoneal, and the lowest part of the ampulla is retroperitoneal because only a small area of its anterior wall is covered by the peritoneum.

The line along which the peritoneum leaves the wall of the intestine descends obliquely from back to front. With the gradual loss of the peritoneal covering by the wall of the pelvic part of the

rectum it is replaced by the visceral layer of the pelvic fascia forming the sheath of the rectum.

The perineal part of the rectum has the appearance of a longitudinal slit and opens in a depression, in the **anal (gluteal) cleft** *(crena ani)*, by the **anus** almost in the middle of the distance between the coccyx and root of the scrotum in males or the posterior commissure of the labium majus in females, at the level of the transverse line connecting both ischial tuberosities. The perineal part is 3–4 cm long.

Structure of the wall of the rectum. The **serous coat (peritoneum)** *(tunica serosa)* is a component of the wall of the rectum only for a small distance, as it is mentioned above. The extraperitoneal portion of the pelvic part of the rectum is enclosed in the visceral layer of the pelvic fascia; the fascia is not in direct contact with the muscular coat of the rectal wall; between them lies a layer of fatty tissue and pass nerves, blood vessels supplying the rectum, and lymph glands *(nodi lymphatici anales)*. The anterior part of the rectal fascia is a sheet separating the rectum from the organs lying anteriorly of it (the urinary bladder, prostate, and others; see below). This sheet is a derivative of the fused serous layers of the deepest portion of the peritoneal pouch of the true pelvis; it stretches from the floor of the recto-uterine, or rectovaginal, pouch in females, and rectovesical pouch in males to the perineal body and is called the rectovaginal septum in females and rectovesical septum in males. Dorsally, the rectal fascia terminates on the midline of the posterior wall of the rectum.

The **muscular coat of the rectum** *(tunica muscularis recti)* consists of two layers: a thinner outer, **longitudinal layer** *(stratum longitudinale)* and a thicker inner **circular layer** *(stratum circulare)*. The longitudinal layer is a continuation of the taeniae of the pelvic colon which become wider here and invest the rectum completely. The longitudinal muscle fibres are stronger on the anterior and posterior walls. Fibres of the rectococcygeal muscle *(musculus rectococcygeus)* stretching from the anterior sacrococcygeal ligament are interlaced posteriorly into the longitudinal muscular layer of the lower portion of the ampulla. Some of the muscle fibres of the longitudinal layer are interlaced into the levator ani muscle *(musculus levator ani)*, others reach the skin.

The circular muscular layer of the rectum extends to the anus where it thickens to form, as it is indicated above, the **sphincter ani internus muscle** *(musculus sphincter ani internus)*. In front of the anus the fibres of its muscles interlace with the sphincter of the membranous part of the urethra in males and with the vaginal muscles in females. The **sphincter ani externus muscle** *(musculus sphincter ani externus)* (Figs 457, 458) is in the subcutaneous fat surrounding the anus. It belongs to the group of perineal striated muscles. Its external part, lying closer to the surface, embraces the medial part of the levator ani muscle; the portion lying deeper adjoins the circular layer of the rectum which forms here the sphincter ani internus muscle. A band of the levator ani muscle penetrates the space between the sphincter internus and externus muscles. The anterior portion of the levator ani muscle, called the pubococcygeus muscle *(musculus pubococcygeus)*, loops the perineal flexure of the rectum posteriorly.

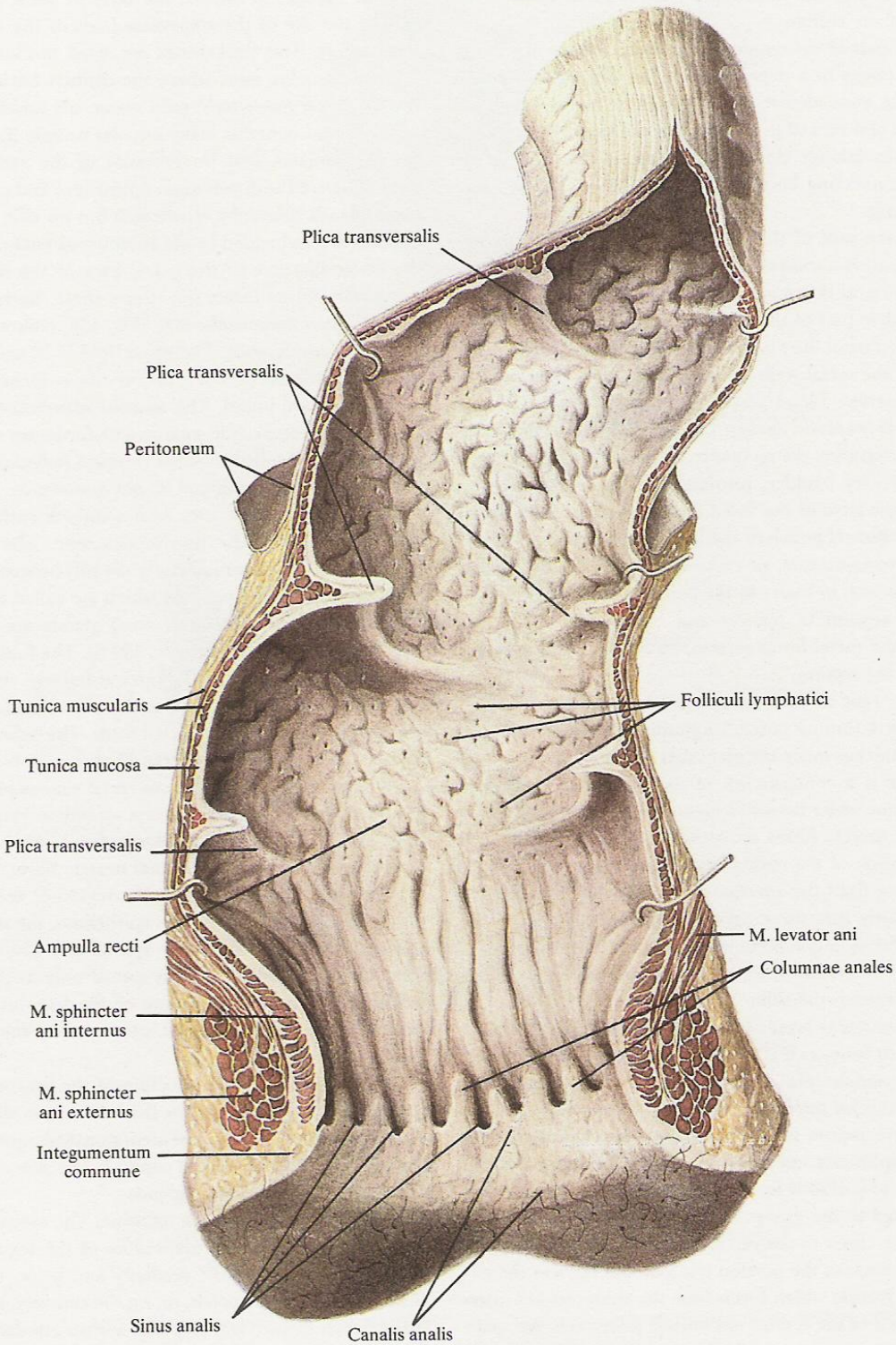
The muscles of the circular layer of the rectum form thickenings at the site of the transverse folds of the mucous membrane (see below). The thickenings are most marked at a distance of 6–7 cm from the anus where the distinct **horizontal folds of the rectum** *(plicae transversales recti)* occur; the middle one is most pronounced and contains many circular muscle fibres.

The **mucous coat (membrane) of the rectum** *(tunica mucosa recti)* is covered with columnar epithelium and contains crypts with **rectal glands** *(glandulae intestinales)* but no villi; solitary lymphatic nodules are embedded in the **submucous coat** *(tela submucosa)*. For the whole distance of the pelvic part of the rectum the mucous membrane forms three, sometimes more, **horizontal folds of the rectum** *(plicae transversales recti)* (Fig. 458) embracing half of the intestinal circumference. The upper fold is 10 cm from the anus. In addition to the horizontal folds very many inconstant, variously directed folds are found. The mucous membrane of the lower portion of the rectum (the anal canal) forms up to 10 longitudinal folds which are called the **anal columns** *(columnae anales)* (Fig. 458) which increase in width and height downwards. Distal to them is a slightly swollen anular area with a smooth surface of the mucous membrane, this is the transitional zone. The prominent transitional zone as if closes inferiorly the pits between the columns and transforms them into pouches which are called the **anal sinuses** *(sinus anales)*. The circumanal (anal) glands are embedded in the floor of the sinuses (Figs 459 A, 459 B). The folds of the intermediate zone, which close the sinuses inferiorly, are called the **anal valves** *(valvulae anales)*. Distal to the transitional zone is the skin of the anus which gathers in radial folds. The submucous coat in the region of the columns and transitional zone is formed of areolar tissue containing the submucous rectal venous plexus. In the transitional zone this plexus forms a complete ring; the submucous layer in the region of the columns contains, besides the venous plexuses, bundles of longitudinal muscle fibres.

The mucous membrane in the region of the columns is lined with nonkeratinized squamous epithelium, the mucous membrane of the sinuses, with columnar epithelium. The crypts of the mucous membrane of the rectum spread only to the zone of the columns. The mucous membrane of the transitional zone is lined with nonkeratinized stratified squamous epithelium which bears papillae.

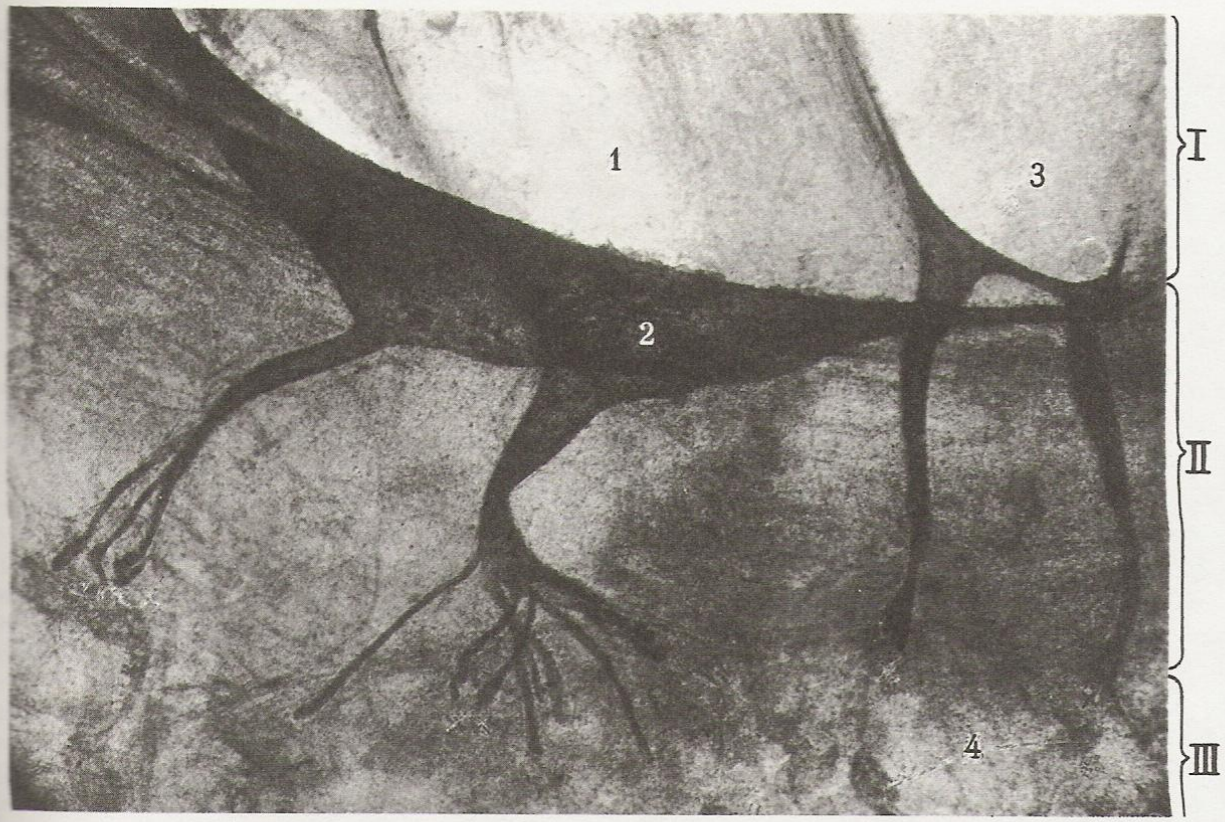
A line formed by the junction of the mucous membrane and skin of the anus is seen below the level of the sinuses. The skin of the anus is lined with pigmented stratified squamous keratinized epithelium with pronounced papillae. The skin contains sebaceous and glomiform circumanal glands.

Topography of the large intestine. The caecum lies in the right iliac fossa 4–5 cm above the middle of the inguinal ligament. Its position varies: it may lie medially and below this level, directly above the inlet of the pelvis, or, on the contrary, it may be found at a high level, in the right hypochondrium, under the right lobe of the liver. The base of the vermiform appendix is projected on a point between the right and middle third of the transverse line connecting both anterosuperior iliac spines (bi-iliac line). Posteriorly the caecum lies on the parietal peritoneum in the region of the



458. *Rectum* ($^3/_4$).

[Mucous coat *(tunica mucosae)*.]



459A. *Circumanal glands* (specimen prepared by A. Kogon).
(Photomicrograph.)

(Isolated glands opening in groups into the main and auxiliary anal sinuses; from a completely stained specimen of rectum.)

Zones of anal canal:
I—columnar (distal part)
II—intermediate (entire)
III—cutaneous (proximal part)
1—main complex anal sinus
2—its auxiliary pouch
3—auxiliary anal sinus
4—circumanal sebaceous gland
XX—branching simple and complex circumanal glands
X—nonbranching circumanal gland

iliac fossa. On the left and inferiorly it is related to the loops of the ileum.

The posterior surface of the ascending colon is separated from the fascia covering the iliacus and the quadratus lumborum muscles and the fascia of the lower portion of the right kidney by areolar retroperitoneal (paracolic) tissue attendant to the colon. On the left and anteriorly the ascending colon is in relation with the loops of the small intestine and the greater omentum.

The right (hepatic) flexure of the colon is on a level with the tenth costal cartilage and is related to the inferior surface of the right lobe of the liver and to the floor of the gall bladder (to the right of it).

The transverse colon lies in the right hypochondrium, the epigastrium, and the left hypochondrium, i.e., on a line connecting the end of the tenth right rib with the end of the ninth left rib. The middle, sagging, part of the intestine may reach the umbilicus or even descend to a lower level.

Anteriorly the transverse colon is separated from the anterior abdominal wall by the greater omentum. Its superior surface is in relation with the inferior surface of the right lobe of the liver, the gall bladder, the greater curvature of the stomach, and the spleen. Inferiorly the transverse colon is related to the loops of the small intestine, posteriorly it adjoins the third part of the duodenum and the pancreas. The transverse colon and its mesentery divide the ab-

459B. *Circumanal glands* (specimen prepared by A. Kogon). (Photomicrograph.)

(Isolated complex circumanal gland from completely stained specimen of rectum.)

1—main parts of gland
2—ducts of main gland
3—common duct
4—opening
5—crypts
6—mucous membrane

dominal cavity topographically into two storeys: an upper storey containing the liver, stomach, and spleen, and a lower storey in which is the entire mass of the loops of the small intestine.

The left (splenic) flexure of the colon is on a level with the ninth costal cartilage or the eighth intercostal space, 4 cm higher than the right (hepatic) flexure. It is in contact with the lower part of the spleen and posteriorly with the left kidney.

The descending colon is related to the anterior surface of the left kidney superiorly. Lower it is separated (just like the ascending colon) from the fascia covering the quadratus lumborum, the transversus abdominis, and the iliacus muscles by the areolar retroperitoneal (paracolic) tissue. The upper part of the descending colon is directed a little obliquely to the right, downwards, and to the front; its other portion descends vertically and to the front. The anterior surface of the descending colon is covered by the loops of the small intestine.

The pelvic colon lies in the left iliac fossa and in the upper part of the cavity of the true pelvis; depending on the width of the mesentery the pelvic colon may pass beyond the midplane of the abdominal cavity into the right half and ascend to the level of the transverse mesocolon. Posteriorly the pelvic colon is separated by the peritoneum from the iliacus and quadratus lumborum muscles as well as the common iliac vessels and the ureter.

As it is indicated above, the pelvic part of the rectum lies in a hollow formed by the sacrum and coccyx. The retrorectal areolar tissue separates the posterior surface of the rectum from the sacrum, and the lateral and inferior surfaces from the muscles of the floor of the pelvis.

The anterior and superior surfaces of the pelvic part of the rectum, which is covered by the peritoneum, are related to the loops of the small intestine and the urinary bladder in males and the body of the uterus and, lower, the uppermost part of the posterior wall of the vagina (the posterior fornix) in females. The peritoneal pararectal folds run on the sides of the pelvic part of the rectum.

The rectovaginal (rectovesical) septum separates the anterior surface of the extraperitoneal part of the rectum from the posterior wall of the urinary bladder (in the middle), the posterior surface of the prostate (lower), and the right and left seminal vesicles and the ampullar portions of the right and left vas deferens (on the sides).

In females the anterior surface of the extraperitoneal part of the rectum is related to the posterior wall of the vagina from which it is separated by the connective-tissue rectovaginal septum.

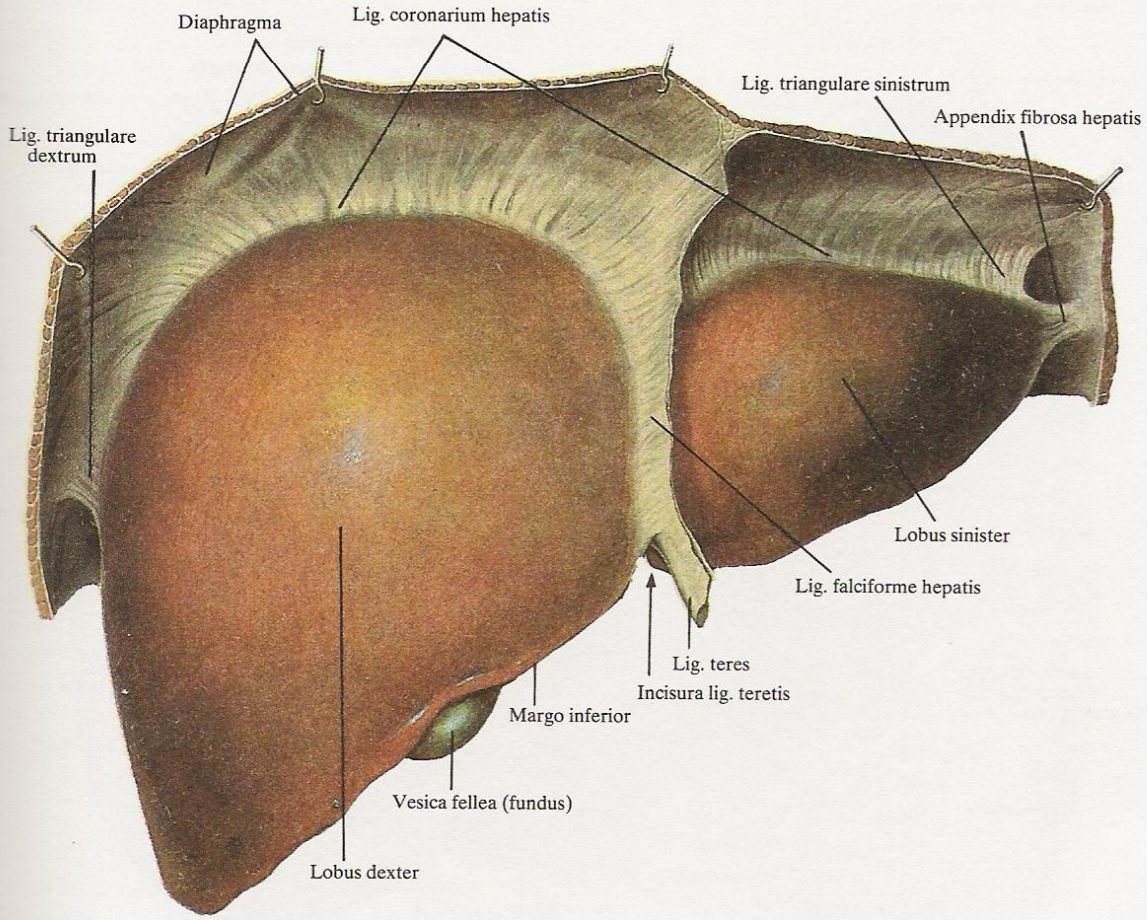
Age features of the large intestine. The caecum of the newborn is funnel-shaped. The ascending colon is short in the newborn and lies under the liver but gradually descends with age and is found in the iliac fossa by the age of 12-14 years. The transverse colon of a newborn is in the epigastrium because its mesentery is short at this age; by the age of 18 months the transverse colon increases almost threefold in length, descends (to the level of the umbilicus in an adult) and sags.

The pelvic colon in children has a long mesentery as a result of which it reaches the level of the transverse mesocolon superiorly or the level of the ascending colon on the right.

The large intestine of a newborn has many folds and intestinal glands but the taeniae and sacculations (haustrae) are less developed. At old age the taeniae are thin and the sacculations and folds reduce in number and size. The position of the rectum in children is almost vertical because the sacrum is straighter in relation to the vertebral column.

Innervation: the colon—the superior and inferior mesenteric plexus (*plexus mesenterici superior* et *inferior*); the rectum—the haemorrhoidal nerves *(nervi rectales) (plexus rectalis)*.

Blood supply: the colon—the superior and inferior mesenteric arteries (*arteriae mesentericae superior* et *inferior*); the rectum—the inferior mesenteric, internal iliac, and median sacral arteries (*arteriae mesenterica inferior*, *iliaca interna* et *sacralis mediana*).



460. *Liver (hepar);* superior aspect ($^2/_3$).
[Upper surface *(facies diaphragmatica)*.]

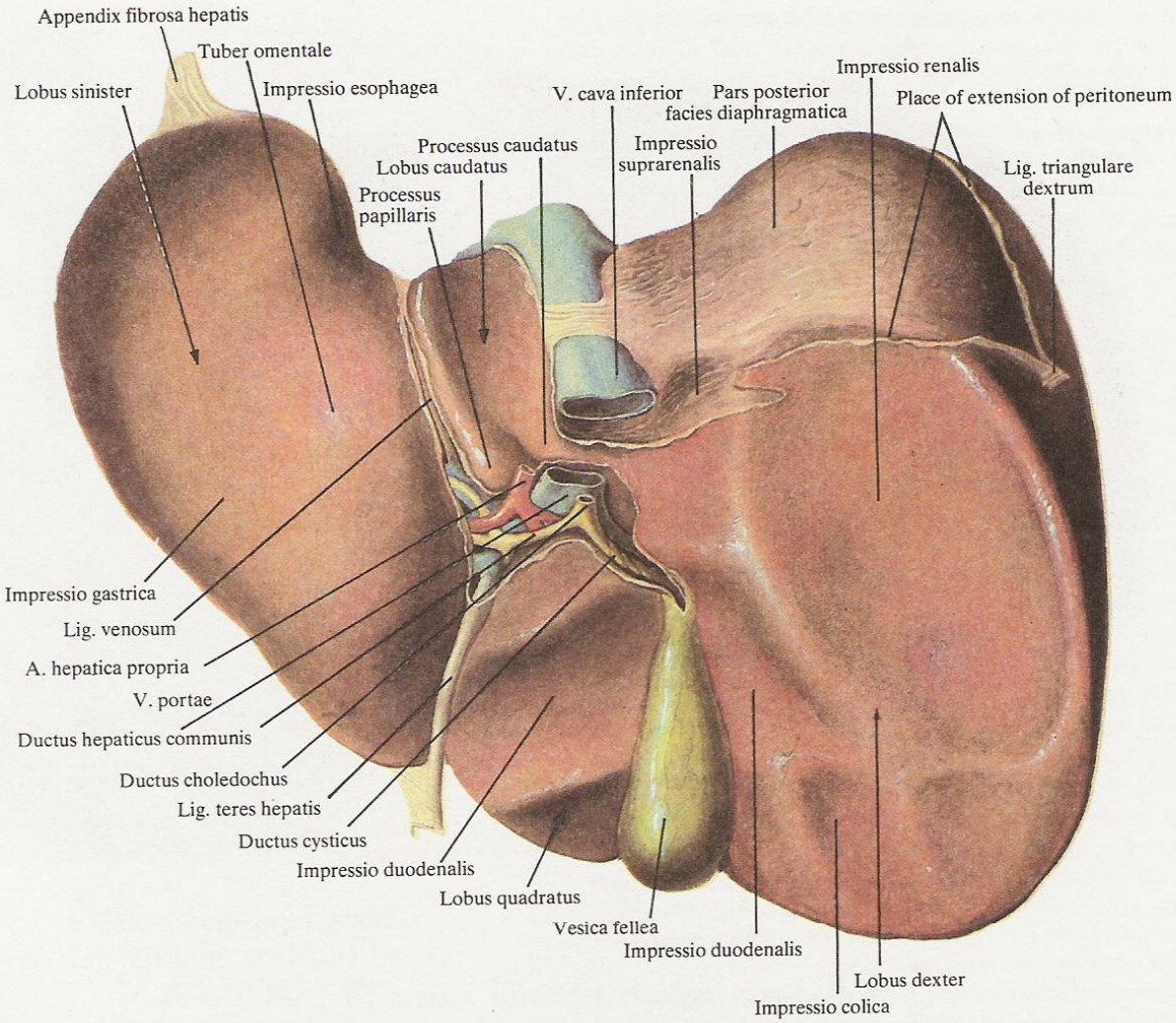
THE LIVER

The liver *(hepar)* (Figs 460–467, 474) is the largest digestive gland. It occupies the upper part of the abdominal cavity under the diaphragm (see Fig. 476), on the right side for the most part. The gland rather resembles the cap of a large mushroom in shape or is wedge-shaped. It has a convex upper and a slightly concave lower surface. The convexity, however, is not symmetric because not the central part of the liver but its right posterior part is most convex and bulky and narrows wedge-like to the front and to the left. The right to left size of the liver varies from 26 to 30 cm; the anteroposterior size of the right lobe is 20–22 cm and that of the left lobe is 15–16 cm; the maximum thickness (right lobe) varies from 6 to 9 cm. The liver weighs 1500 g on the average. It is reddish-brown in colour and pliant in consistency.

The liver has a convex upper surface *(facies diaphragmatica)*, a lower, or visceral surface *(facies visceralis)* which is concave in places, a sharp lower border *(margo inferior)* separating the upper and lower surfaces in front, and a slightly convex posterior part *(pars posterior)* of the upper surface, which is called the posterior surface of the liver.

The lower border of the liver bears a **notch for the ligamentum teres** *(incisura ligamenti teretis)* to the right of which is a fossa for the gall bladder.

The **upper surface** *(facies diaphragmatica)* is convex and corresponds to the shape of the dome of the diaphragm. The convexity is greatest on the right, nearer to the posterior border of the diaphragm, where the liver is the thickest. From the highest point the surface slants to the sharp lower border and to the left border of the liver, and passes steeply to the back, to the posterior and right parts of the upper surface of the liver. From the upper surface of the liver to the diaphragm ascends a sagittal peritoneal **falciform**



461. *Liver (hepar);* inferior aspect ($^2/_3$).

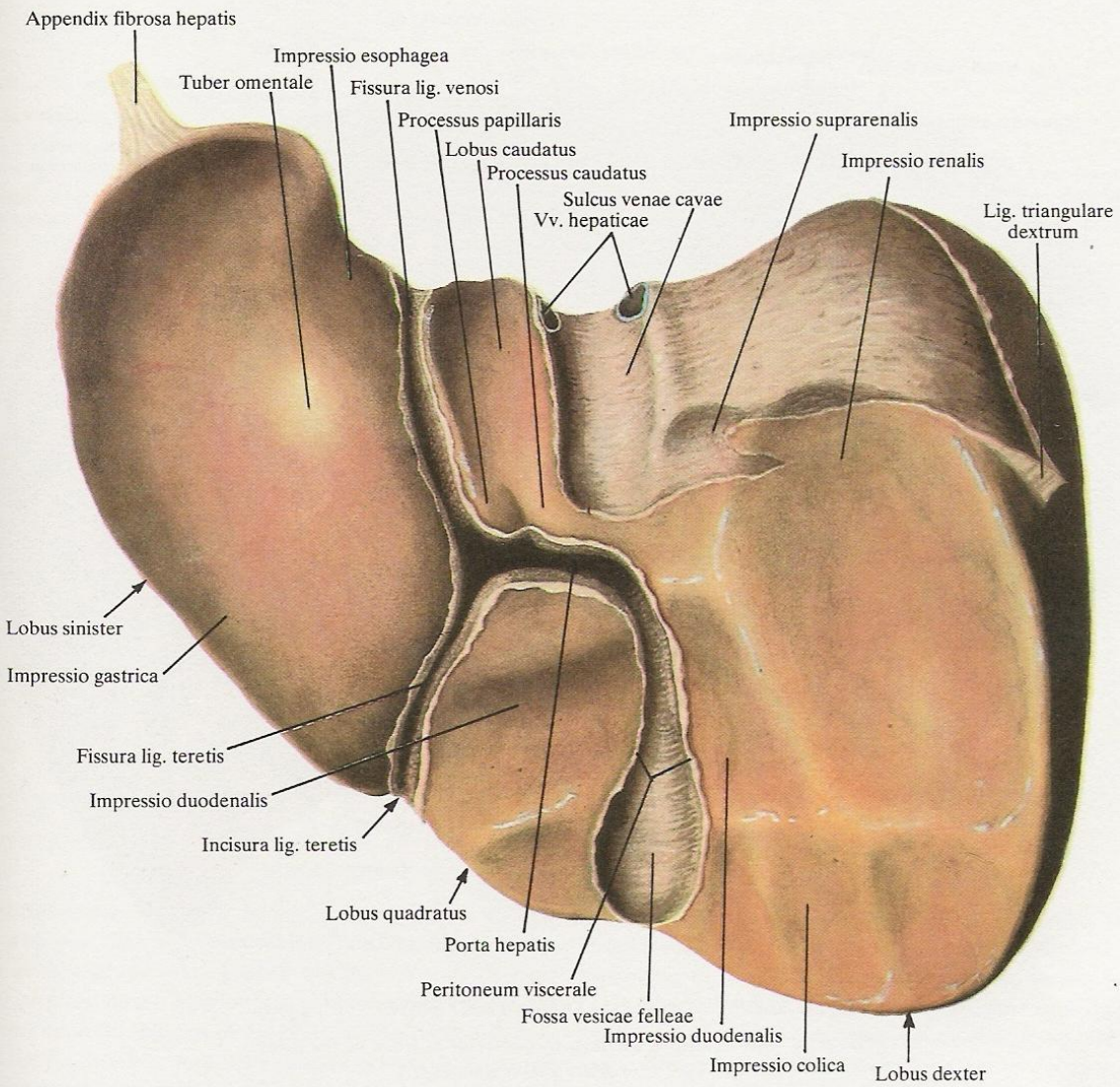
[Lower surface *(facies visceralis)*.]

ligament of the liver *(ligamentum falciforme hepatis)* which passes from the lower border of the liver to the back for a distance of approximately two-thirds of the width of the liver; posteriorly the layers of the ligament diverge to the right and to the left to be continuous with the **coronary ligament of the liver** *(ligamentum coronarium hepatis)*. The falciform ligament separates the liver on the upper surface into two parts—the **right lobe of the liver** *(lobus hepatis dexter)* which is the largest and the thickest, and the **left lobe of the liver** *(lobus hepatis sinister)* which is smaller. The right lobe is under the right dome of the diaphragm, the left lobe is under the left dome. A small **cardiac impression** *(impressio cardiaca)* is visible on the upper surface of the left lobe, which corresponds to the position of the heart above the diaphragm.

The following parts are distinguished on the upper surface of the liver: the **superior surface** *(pars superior)* facing the central tendon of the diaphragm; the **anterior surface** *(pars anterior)* which is directed to the front, to the costal part of the diaphragm and to the anterior abdominal wall in the epigastrium (left lobe); the **right surface** *(pars dextra)* which is directed to the right to the lateral abdominal wall (corresponding to the axillary line); the **posterior surface** *(pars posterior)* facing the back.

The **lower surface** *(facies visceralis)* of the liver is uneven and slightly concave, conforming to the outlines of the underlying organs. It bears three fissures which divide it into four lobes. Two fissures run sagittally almost parallel to each other from the anterior to the posterior border of the lower surface; approximately in the middle of this distance they are connected as if by a cross bar by a third, transverse fissure.

The left fissure consists of two parts: an anterior part extending to the transverse fissure, and a posterior part stretching from it to

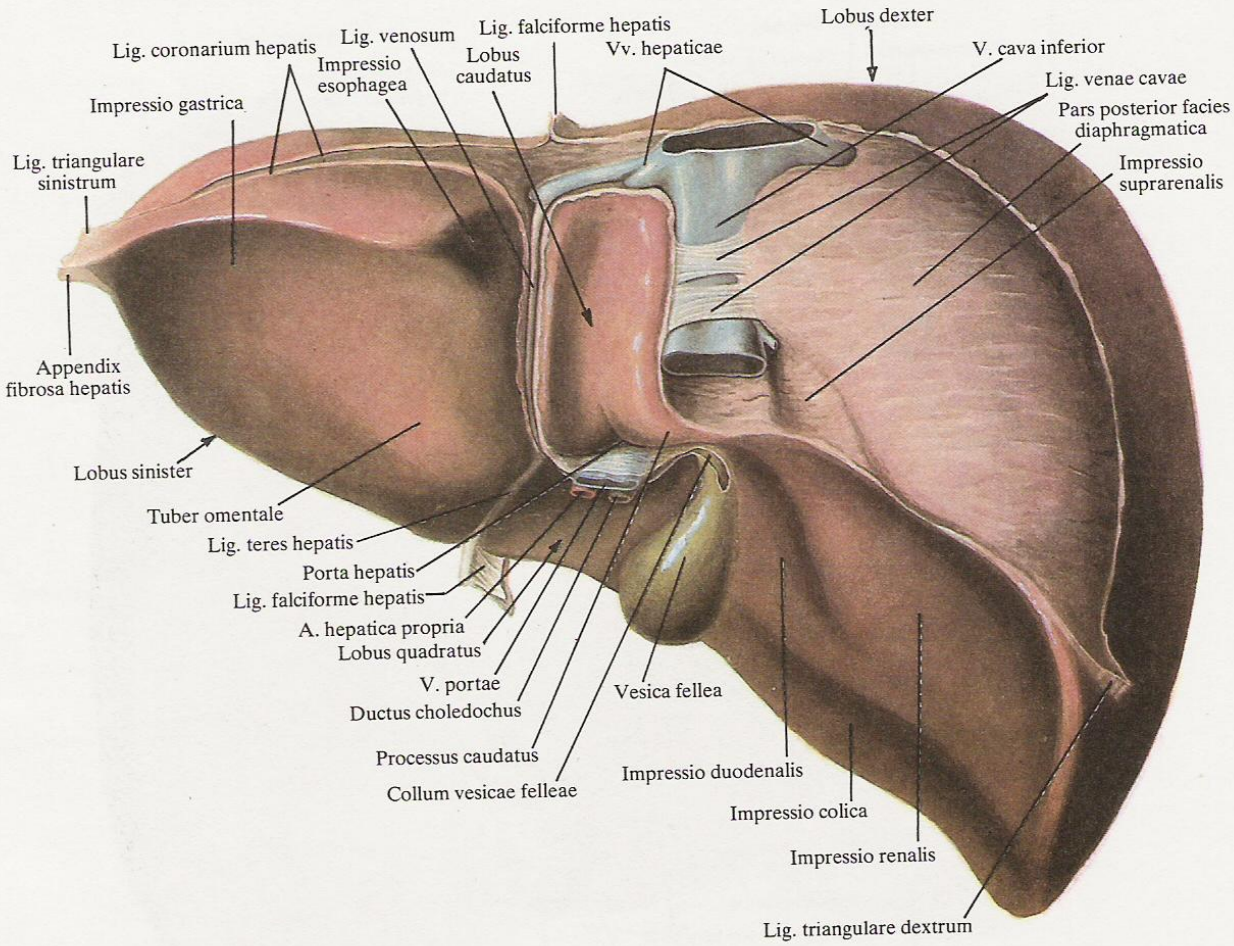


462. *Liver (hepar);* lower surface ($^2/_3$).

(The gall bladder and vessels are removed.)

the back. The anterior one is the deepest and is called the **fissure for the ligamentum teres** *(fissura ligamenti teretis)*; in the embryonal period this is the **groove for the umbilical vein** *(sulcus venae umbilicalis)*; the fissure arises on the lower border of the liver from the **notch for the ligamentum teres** *(incisura ligamenti teretis)* and lodges the **round ligament of the liver** *(ligamentum teres hepatis)* which passes in front and below the umbilicus and contains the obliterated umbilical vein *(vena umbilicalis)*. The posterior part of the left fissure is the **fissure for the ligamentum venosum** *(fissura ligamenti venosi)*; in the embryonal period it is the **fossa ductus venosi**; it runs backwards from the transverse fissure to the left hepatic vein. The position of the left fissure on the lower surface corresponds to the line of attachment of the falciform ligament on the upper surface of the liver. At the same time, the round ligament of the liver is enclosed in the lower border of the falciform ligament on its free anterior area.

The right fissure is a longitudinal depression and is called the **fossa for the gall bladder** *(fossa vesicae felleae)*; the lower border of the liver has a corresponding notch. The fossa is shallower than the fissure for the ligamentum teres but is wider and is an impression of the gall bladder *(vesica fellea)* lodged in it. The fossa stretches backwards to the transverse fissure and is continuous posteriorly from it with the **groove for the vena cava** *(sulcus venae cavae)*.



463. *Liver (hepar);* posterior aspect ($^2/_3$).

[Posterior part of upper surface, or posterior surface of the liver *(pars posterior faciei diaphragmaticae)*.]

The transverse fissure (Figs 461, 462) is the **porta hepatis** which lodges the **proper hepatic artery** *(arteria hepatica propria)*, the **hepatic duct** *(ductus hepaticus)*, and the **portal vein** *(vena portae)*. Both the artery and the vein separate into the main, right and left, branches in the porta hepatis.

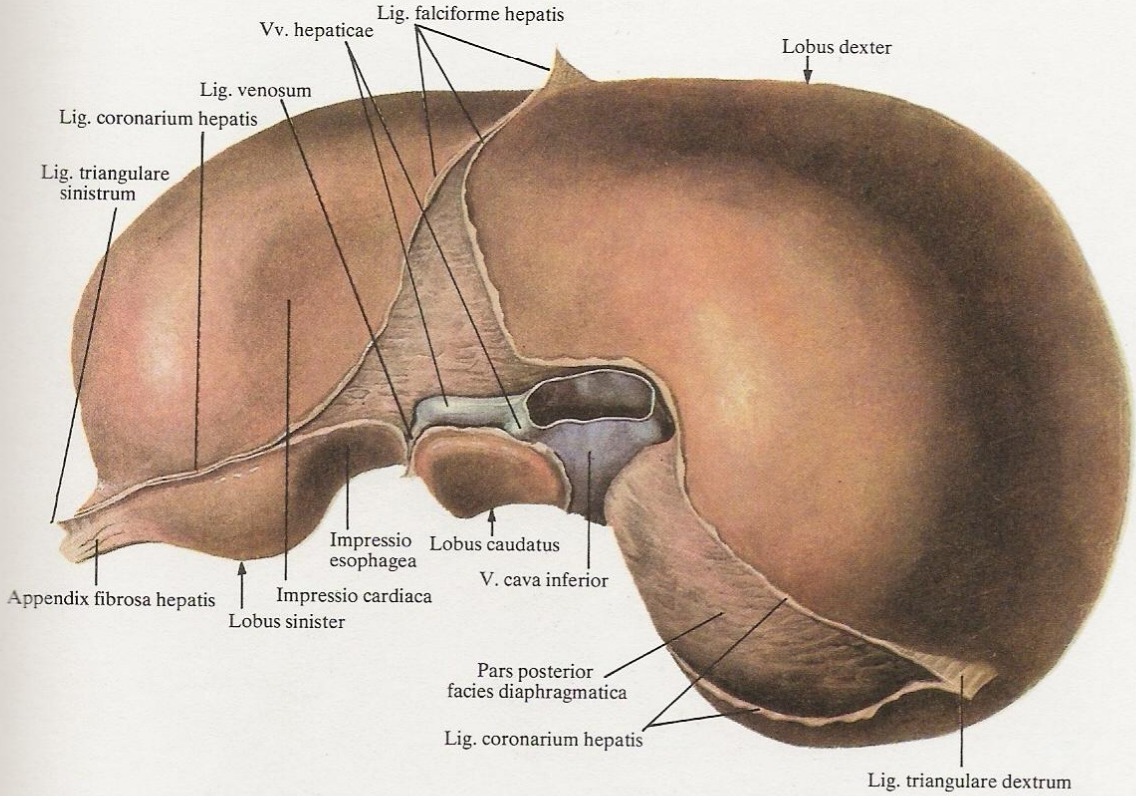
The three fissures divide the lower surface of the liver into four lobes. The left fissure forms the right boundary of the lower surface of the left lobe; the right fissure forms the left boundary of the lower surface of the right lobe of the liver.

Between the right and left fissures on the lower surface of the liver is a middle area which is divided by the transverse fissure into the anterior and posterior areas. The anterior area represents the quadrate lobe *(lobus quadratus)*; the posterior area, the caudate lobe of the liver *(lobus caudatus hepatis)*.

The lower surface of the right lobe of the liver bears nearer to the inferior border the **colic impression** *(impressio colica)*. Posterior to it, on the right is a large depression for the adjoining right kidney, which is called the **renal impression** *(impressio renalis)*; on the left, next to the right fissure is the **duodenal impression** *(impressio duodenalis)*, and still further to the back, to the left of the renal impression, is the **suprarenal impression** *(impressio suprarenalis)* for the right suprarenal gland.

The **quadrate lobe of the liver** *(lobus quadratus hepatis)* is bounded by the fossa of the gall bladder on the right, by the fissure for the ligamentum teres on the left, by the inferior border anteriorly, and by the porta hepatis posteriorly. In the middle of the breadth of the quadrate lobe is a depression shaped like a wide transverse groove, this is the **duodenal impression** *(impressio duodenalis)*; it continues from the right lobe of the liver.

The **caudate lobe of the liver** *(lobus caudatus hepatis)* lies to the back of the porta hepatis and is bounded anteriorly by the transverse fissure of porta hepatis, on the right by the groove for the



464. *Liver (hepar);* posterosuperior surface ($^2/_3$).

vena cava *(sulcus venae cavae)*, on the left by the fissure for the ligamentum venosum *(fissura ligamenti venosi)*, and posteriorly by the posterior surface of the liver. A small **papillary process** *(processus papillaris)* projects on the anterior area of the caudate lobe on the left; it abuts upon the left part of the porta hepatis posteriorly. On the right the caudate lobe forms the **caudate process** *(processus caudatus)* which passes to the right, bridges the space between the posterior end of the fossa for the gall bladder and the anterior end of the groove for the vena cava, and is continuous with the right lobe of the liver.

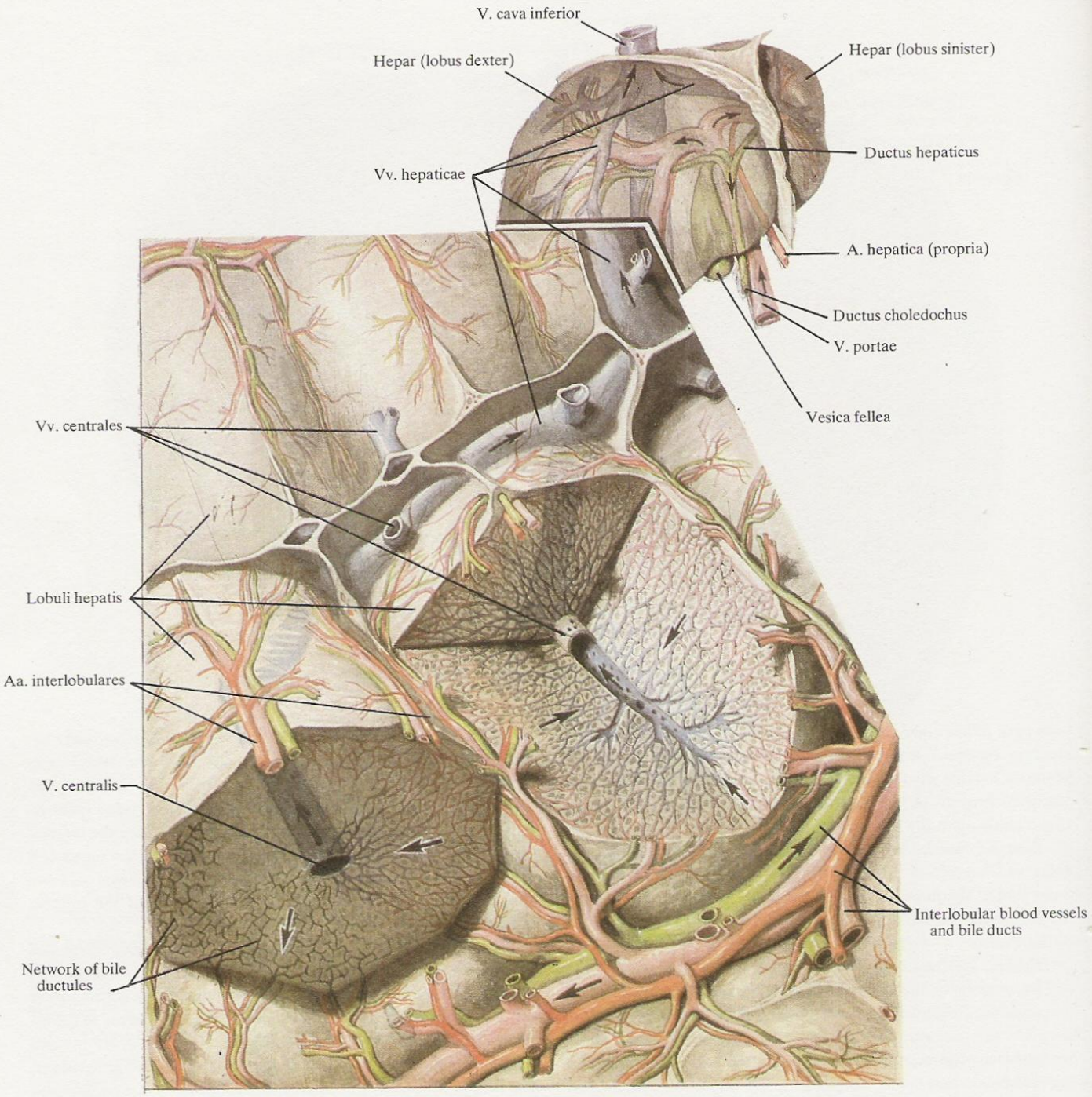
The **left lobe of the liver** *(lobus hepatis sinister)* has on its lower surface, nearer to the lower border, a swelling called the **tuber omentale** which faces the lesser omentum *(omentum minus)* (see below). On the posterior border of the left lobe, directly next to the fissure for the ligamentum venosum, is a depression for the adjoining abdominal part of the oesophagus; it is called the **oesophageal impression** *(impressio esophagea)*.

The **gastric impression** *(impressio gastrica)* is to the left of these structures, nearer to the back, on the lower surface of the left lobe.

The posterior part of the upper surface *(pars posterior faciei diaphragmaticae)*, or the posterior surface of the liver (Figs 463, 464) is a rather wide, slightly rounded area of the liver which is not covered by the peritoneum; this is the **bare area** *(area nuda)*. The posterior part forms a concavity corresponding to the adjoining vertebral column. The area is wide in the centre but gradually becomes narrower on the periphery, on the right and left. Corresponding to the right lobe, it has a groove for the inferior vena cava which is called the **groove for the vena cava** *(sulcus venae cavae)*. Three hepatic veins *(venae hepaticae)* draining into the inferior vena cava are seen in the tissue of the liver closer to the upper end of the groove. The margins of the groove for the vena cava are joined by means of a connective-tissue ligament of the inferior vena cava (Figs 461, 463).

The liver is almost completely covered by the peritoneum and can therefore be considered a mesoperitoneal organ (some authors claim it to be intraperitoneal). The peritoneum covers its upper and lower surfaces and the lower border. However, areas of different width, where ligaments approach the liver and where the gall bladder is adjacent to it, remain not covered by the peritoneum. The largest diamond-shaped area that is devoid of the peritoneum is on the posterior surface of the liver, where the liver is in direct contact with the posterior abdominal wall. Another area is that on which the gall bladder lies.

Peritoneal ligaments. The **falciform ligament of the liver** *(ligamentum falciforme hepatis)* suspends the liver from the diaphragm. It is a duplicature of the peritoneum and joins the visceral peritoneum covering the upper surface of the liver with the parietal peritoneum investing the lower surface of the diaphragm. Anteriorly



465. *Lobules of liver* (diagram).

the falciform ligament passes over to the anterior abdominal wall as a sagittal septum and, gradually becoming narrower, approaches the umbilicus. As it is pointed out above, the round ligament of the liver *(ligamentum teres hepatis)* is lodged in its free border. Ontogenetically, the falciform ligament is part of the ventral mesentery of the stomach. Both layers of the ligament approach posteriorly at a right angle another peritoneal ligament which is known as the **coronary ligament of the liver** *(ligamentum coronarium hepatis)*. This ligament consists of two layers, one passing from the upper surface of the liver and the other from the lower surface, and at-

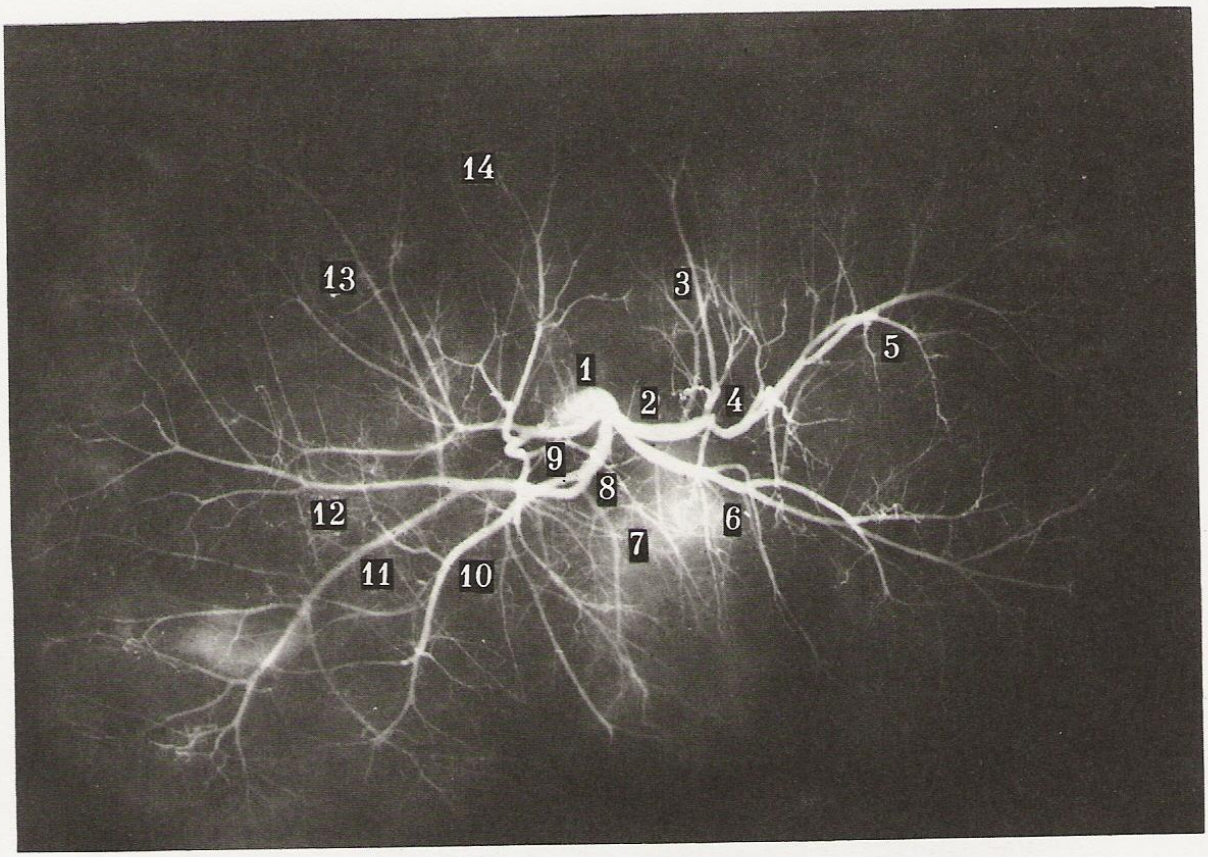
466A. *Intrahepatic bile ducts and branches of portal vein* (specimen prepared by N. Lebedints).
(Photograph of a corrosion preparation.)
(Intrahepatic ducts are coloured yellow.)

taches the posterior, extraperitoneal surface of the liver to the posterior abdominal wall.

In the direction of the right and left ends of the posterior surface of the liver both layers of the coronary ligament meet to form a duplicature. The extraperitoneal area of the posterior surface is widest where it corresponds to the posterior surface of the right lobe of the liver, in the region of the thickest part of the organ. The extraperitoneal area of the right lobe is almost triangular, with the apex facing to the right and the base directed to the centre. The inferior vena cava lies here in the widest part. On the posterior surface of the left lobe, the extraperitoneal area between the layers of the coronary ligament is triangular in shape, with the apex facing to the left and the base also at the inferior vena cava, but on the left this area is smaller and narrower. Together these triangular areas make a rhombus shape. The falciform ligament approaches the coronary ligament, and the left layer of its duplicature is continuous with the part of the coronary ligament on the left lobe while the right layer is continuous with the part of the ligament on the right lobe. Posteriorly, the coronary ligament is directly continuous with the layers of the posterior parietal peritoneum. At the right and left ends of the liver the coronary ligament forms small triangular duplicatures passing for a small distance to the right and left and attaching the liver to the diaphragm; these are the right and left triangular ligaments *(ligamenta triangularia dextrum* et *sinistrum).*

The visceral peritoneum on the lower surface of the liver gives rise to ligaments which connect it to the lesser curvature of the stomach, the **hepatogastric ligament** *(ligamentum hepatogastricum)*, and to the first part of the duodenum, the **hepatoduodenal ligament** *(ligamentum hepatoduodenale)*. These ligaments extend almost frontally and are continuous one with the other. On the surface of the liver they arise on the left from the visceral peritoneum of the posterior part of the fissure for the ligamentum teres (the hepatogastric ligament) and on the right, from the visceral peritoneum in the region of the porta hepatis (the hepatoduodenal ligament).

Structure of the liver. The surface of the liver is enclosed in a **serous coat** *(tunica serosa)* with an underlying **subserous coat** *(tela subserosa)* and a **fibrous coat** *(tunica fibrosa)*. The connective tissue of the fibrous coat together with the vessels penetrates the parenchyma through the porta hepatis and the posterior end of the fissure for the ligamentum teres as the **hepatobiliary capsule** *(capsula fibrosa perivascularis)*. The processes of the capsule contain bile



466B. *Intrahepatic bile ducts* (specimen prepared by N. Lebedints). (Photograph of radiograph, ⅔.)

1—common hepatic duct
2—left hepatic duct
3—medial duct of left hepatic duct
4—anterior (main) duct of left lobe
5—lateral duct of left hepatic duct
6—posterior (main) duct of left lobe
7—right duct of caudate lobe
8—posterior duct of right hepatic duct
9—anterior duct of right hepatic duct
10—superoposterior duct of right lobe
11—posteroinferior duct of right lobe
12—inferior main duct of right lobe
13—anteroinferior duct of right lobe
14—paracystic duct (lies subperitoneally in the right cystohepatic angle)

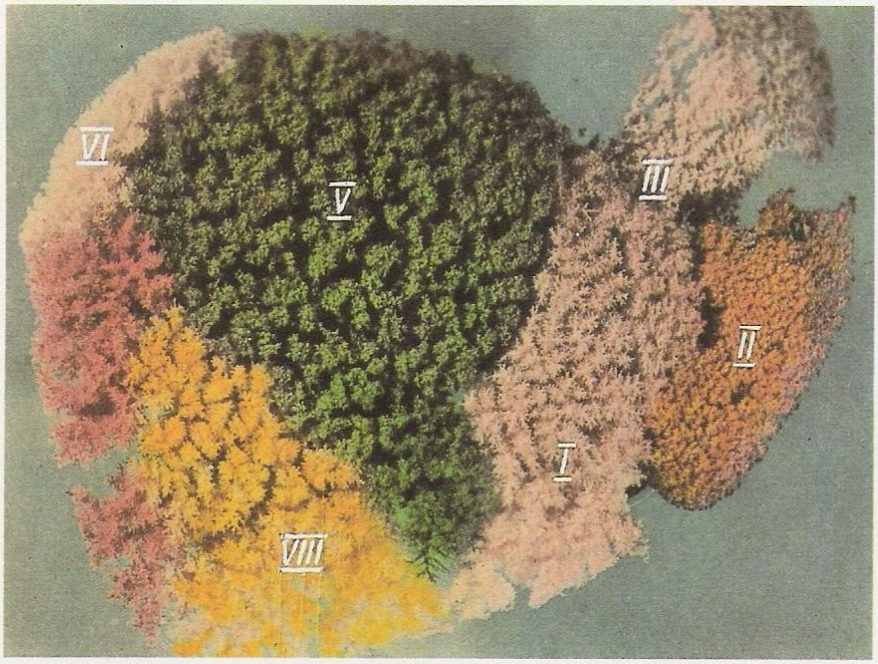
ducts, branches of the portal vein and of the proper hepatic artery. Consequently, the fibrous coat and its intrahepatic processes form a connective-tissue framework whose compartments contain the lobules of the liver.

The **lobule of the liver** *(lobulus hepaticus)* (Fig. 465) is 1–2 mm in size and consists of liver cells called **hepatocytes** *(hepaticocyti)* which form **hepatic plates** *(laminae hepaticae)*. In the centre of the lobule is a **central vein** *(vena centralis)*, and around the lobule lie **interlobular arteries** and **veins** (*arteriae interlobulares* et *venae interlobulares*) which give rise to **interlobular capillaries** *(vasa capillaria interlobularia)*. The interlobular capillaries enter the lobule in which they are continuous with **sinusoids** *(vasa sinusoidea)* lying between the hepatic plates. The sinusoids contain mixed arterial and venous (portal) blood and drain into a central vein. The central veins drain into the **sublobular** (collecting) **veins** *(venae sublobulares)* which in turn drain into the **right, middle,** and **left hepatic veins** (*venae hepaticae dextrae, mediae* et *sinistrae*).

Between the hepatocytes are the **biliary canaliculi** *(canaliculi biliferi)* which drain into the **bile ductules** *(ductuli biliferi)*; the latter unite outside the lobules to form the **interlobular bile ducts** *(ductus interlobulares biliferi)*. The interlobular bile ducts form segmental ducts (Figs 467 A, 467 B).

Based on the results of study of the intrahepatic bile ducts, a modern idea of the lobes and segments of the liver developed (Figs 466, 467). A new boundary between the right and left lobes of the liver (*lobi hepatis dexter* et *sinister*) is now generally recognized. It passes through the fossa for the gall bladder and the groove for the (inferior) vena cava (the previously accepted boundary was on the line of attachment of the falciform ligament). The quadrate lobe *(lobus quadratus)* is now regarded a part of the left lobe; in view of this the left lobe, in the previous sense, is more suitable to be named the left lobe proper. The caudate lobe *(lobus caudatus)* is related neither to the right nor the left lobe, though some authors consider it to be a part of the left lobe.

The **right lobe of the liver** *(lobus hepatis dexter)* has an **anterior** and a **posterior segment** (*segmentum anterius* et *segmentum posterius*).



467A. *Segments of liver;* superior aspect (specimen prepared by K. Kudaibergenov). (Photograph of polychromatic corrosion specimen.)

I—anterior segment of left paramedian sector
II—segment of left lateral sector
III—segment of left dorsal sector
IV—posterior segment of left paramedian sector
V—posterior segment of right paramedian sector
VI—posterior segment of right lateral sector
VII—anterior segment of right lateral sector
VIII—anterior segment of right paramedian sector

The anterior segment actually corresponds to the anteromedial area of the right lobe. It consists of the upper and anterior parts of the upper surface of the right lobe and the anteromedial part of the lower surface adjoining the fossa for the gall bladder on the right. The posterior segment corresponds to the posterolateral area of the right lobe. It consists of the right and posterior surfaces of the upper surface of the right lobe and the posterolateral part of its lower surface.

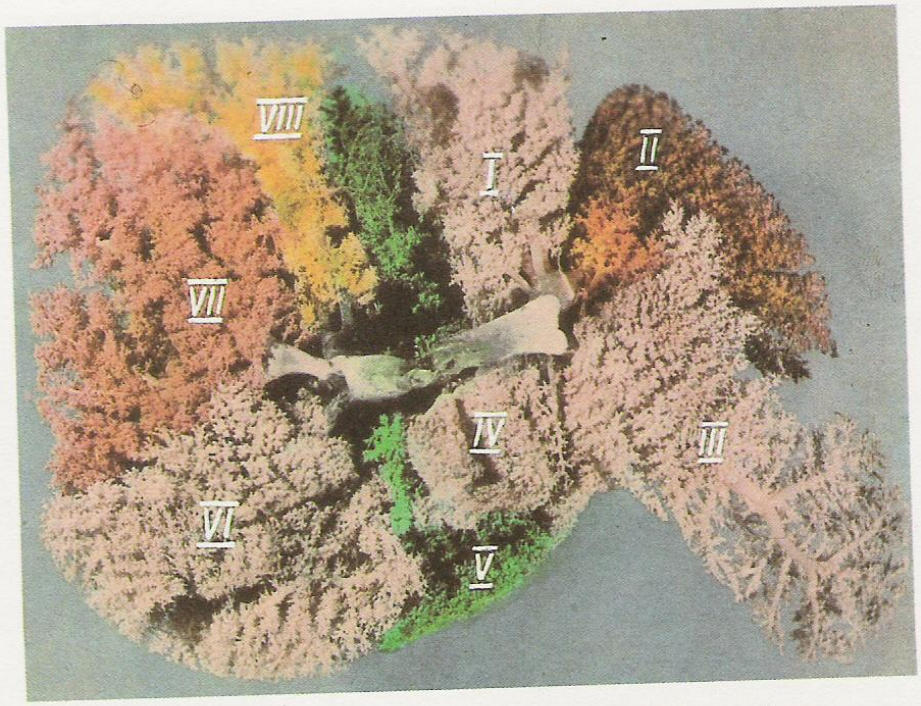
The **left lobe of the liver** *(lobus hepatis sinister)* is formed by the medial and **lateral segments** (*segmentum mediale* et *segmentum laterale*) the boundary between which passes on the falciform ligament through the fissures for the ligamentum teres and ligamentum venosum. A **quadrate portion** *(pars quadrata)* corresponding to the quadrate **lobe** *(lobus quadratus)* is distinguished in the medial segment. The lateral segment corresponds to the left lobe proper.

Each segment is divided into posterosuperior and antero-inferior area which are segments of the second order. Most authors acknowledge the scheme of the segmental structure of the liver, according to which the anterior segment of the right lobe is divided into segments V and VIII, the posterior segment of the right lobe—into segments VI and VII, the lateral segment of the left lobe—into segments II and III; the medial segment of the left lobe (segment IV) and the caudate lobe (segment I) are regarded as single-segment areas of the liver.

The boundaries between the segments of the liver are individually variable.

The lobes and segments of the liver have their own bile ducts and branches of the portal vein and proper hepatic artery (Figs 466 A, 466 B; 467 A, 467 B). The right lobe is drained via the **right hepatic duct** *(ductus hepaticus dexter)* which has an **anterior** and **posterior duct** (*ramus anterior* et *ramus posterior*). The left lobe of the liver is drained by the **left hepatic duct** *(ductus hepaticus sinister)* which has a **lateral** and **medial duct** (*ramus medialis* et *ramus lateralis*). The caudate lobe is drained by the **right** and **left ducts of the caudate lobe** (*ductus lobi caudati dexter* et *ductus lobi caudati sinister*).

The anterior duct of the right hepatic duct is formed by union of the ducts of segments V and VIII; the posterior duct—by the ducts of the VI and VII segments; the lateral duct of the left hepatic duct is formed by union of the ducts of segments II and III. The ducts of the quadrate lobe open into the medial duct of the left hepatic duct, into the duct of segment IV. The right and left ducts of the caudate lobe (the ducts of segment I) may open together or separately into the right, left, and common hepatic ducts as well as into the posterior duct of the right and the lateral duct of



467B. *Segments of liver;* inferior aspect (specimen prepared by K. Kudaibergenov). (Photograph of a polychromatic corrosion specimen.)

(Designations the same as those in Fig. 467A.)

the left hepatic ducts. Other variants of connection of the ducts of segments I-VIII are encountered. The ducts of segments III and IV are often connected to one another.

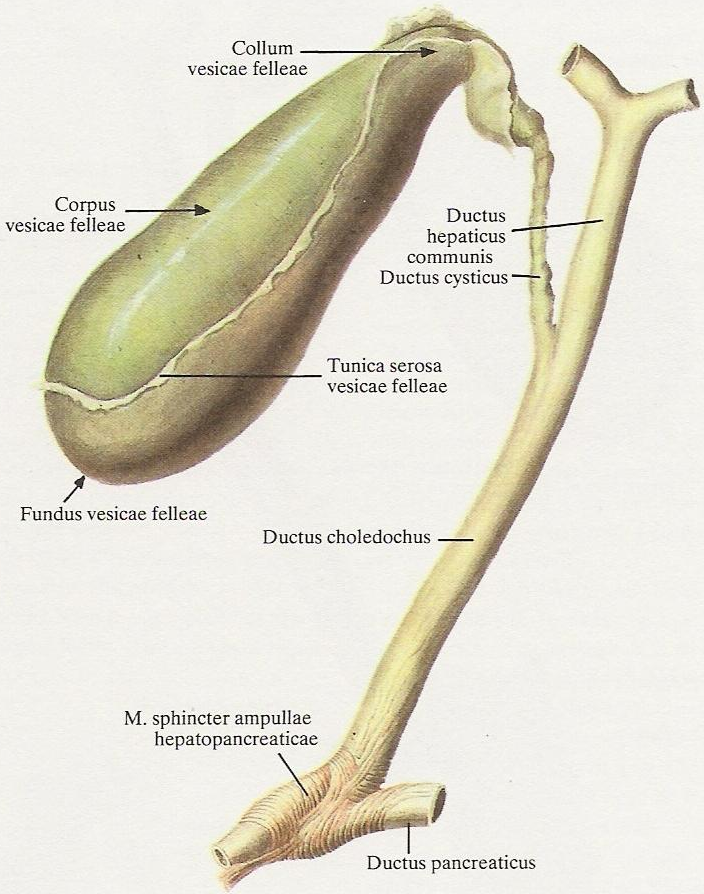
The right and left hepatic ducts unite to form the **common hepatic duct** *(ductus hepaticus communis)* at the anterior margin of the porta hepatis or in the hepatoduodenal ligament. The right and left hepatic ducts and their segmental ducts are inconstant structures; in their absence the other ducts drain into the common hepatic duct. The length of the common hepatic duct varies from 4 to 5 cm, its calibre is from 4 to 5 mm; the mucous membrane is smooth and forms no folds.

Topography of the liver. The liver occupies the right hypochondriac region, the epigastric region, and part of the left hypochondriac region. Its skeletopy is determined by projection on the thoracic walls. The highest point of the position of the liver (right lobe) is found on the right and in front on the mamillary (mediolavicular) line on the level of the fourth intercostal space; the highest point to the left of the sternum (left lobe) is on the level of the fifth intercostal space. The lower boundary of the liver on the right axillary line is on the level of the tenth intercostal space, then passes anteriorly along the right costal arch. At the level of the right mamillary line it comes out from under the arch and passes from right to left upwards across the epigastric region. The lower boundary of the liver crosses the linea alba in the middle of the distance between the xyphoid process and the umbilicus. At the level of the left sixth costal cartilage the lower boundary of the left lobe crosses the costal arch to meet the upper boundary to the left of the sternum.

The position of the boundary of the liver at the back on the right scapular line is determined from the level of the seventh intercostal space (or eighth rib) superiorly to the upper border of the eleventh rib inferiorly.

Syntopy of the liver. The upper surface of the liver is in contact with the right and partly with the left dome of the diaphragm; the anterior surface successively adjoins the costal part of the diaphragm and the anterior abdominal wall; posteriorly the liver is in contact with the tenth and eleventh thoracic vertebrae, the crura of the diaphragm, the abdominal part of the oesophagus, the aorta, and the right suprarenal gland. The lower surface of the liver is in relation with the cardiac portion, body, and pylorus of the stomach, the first part of the duodenum, the right kidney, the right flexure of the colon, and the right end of the transverse colon (the fields of contact of the lower surface of the liver with the adjacent organs are described above). The gall bladder also lies on the lower surface of the liver.

Age features of the liver. The liver of a newborn is relatively large and constitutes one-twentieth of the total body weight (one-fiftieth in the adult); it occupies more than half of the abdominal cavity, and causes the thorax and abdominal wall to bulge out; its lower border is on the level of the umbilicus.



468. *Gall bladder (vesica fellea) and bile ducts (vasa bilifera).*

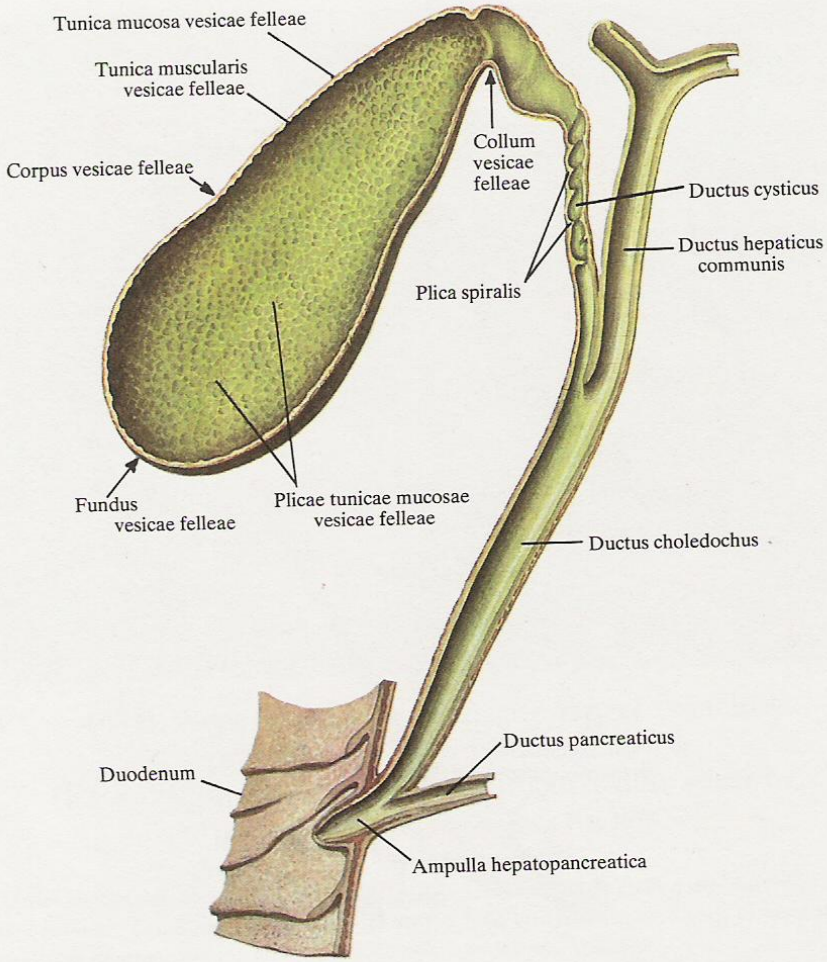
THE GALL BLADDER

The **gall bladder** *(vesica fellea)* (Figs 468, 469) is a sac-like reservoir for bile produced in the liver; it is elongated and one of its ends is wide while the other is narrow; its width gradually reduces in the direction from the fundus to the neck. The length of the gall bladder varies from 8 to 14 cm, its width—from 3 to 5 cm, and its capacity, from 40 to 70 cm^3. It is dark-green in colour and its wall is relatively thin.

The gall bladder has a **fundus** *(fundus vesicae felleae)* which is its distal and widest part, a **body** *(corpus vesicae felleae)* which is its middle part, and a **neck** *(collum vesicae felleae)* which is its peripheral narrow part. The neck is continuous with the **cystic duct** *(ductus cysticus)* by means of which the gall bladder communicates with the **bile duct** *(ductus choledochus)*.

The gall bladder lies on the lower surface of the liver in the fossa for the gall bladder *(fossa vesicae felleae)* (Fig. 462) separating the anterior surface of the right lobe from the quadrate lobe. The fundus of the gall bladder is directed towards the lower border of the liver on which is a notch of the gall bladder from under which it projects. The neck is directed at the porta hepatis and is enclosed together with the cystic duct in the duplicature of the hepatoduodenal ligament. A flexure forms usually at the junction of the body of the gall bladder with its neck as a result of which the neck is set at an angle to the body.

The gall bladder is mesoperitoneal: lying in the fossa for the gall bladder, its superior surface, which is devoid of the peritoneum, is connected to the fibrous coat of the liver by areolar tissue. Its free surface facing downwards into the abdominal cavity is covered by the visceral peritoneum which passes on to it from the adjacent areas of the liver. In some cases the gall bladder may be intraperitoneal and may even have a mesentery. The fundus of the



469. *Gall bladder (vesica fellea) and bile ducts (vasa bilifera)* ($^2/_3$).

(Mucous membrane of gall bladder and bile ducts.)

gall bladder projecting from under the notch of the liver is usually completely covered by the peritoneum.

Structure of the gall bladder. The wall of the gall bladder consists of three coats (except for the upper extraperitoneal wall)—serous *(tunica serosa vesicae felleae)*, muscular *(tunica muscularis vesicae felleae)*, and mucous *(tunica mucosa vesicae felleae)*. Under the peritoneum the wall is enclosed in a thin loose layer of connective tissue; this is the subserous coat of the gall bladder *(tela subserosa vesicae felleae)*; it is developed best on the extraperitoneal surface.

The **muscular coat of the gall bladder** *(tunica muscularis vesicae felleae)* is formed by a single circular layer of smooth muscles among which are also bundles of longitudinal and oblique fibres. The muscular coat is less pronounced in the fundus but stronger in the region of the neck where it is directly continuous with the muscular coat of the cystic duct.

The **mucous coat of the gall bladder** *(tunica mucosa vesicae felleae)* is thin and has an underlying **submucous coat of the gall bladder** *(tela submucosa vesicae felleae)* in the body and neck. The mucous coat forms numerous small **folds of the gall bladder** *(plicae tunicae mucosae vesicae felleae)* lending it the appearance of a net. In the region of the neck the mucous membrane has a few spirally arranged folds passing next to one another. These are called the **spiral valves** *(plicae spirales)*; they are also present in the cystic duct. The mucous coat of the gall bladder is lined with single-layer columnar epithelium; glands are embedded in the submucous coat of the neck (Fig. 470).

Topography of the gall bladder. The fundus of the gall bladder is projected onto the anterior abdominal wall in an angle formed by the lateral border of the right rectus abdominis muscle and the margin of the right costal arch, which corresponds to the

end of the ninth costal cartilage. The lower surface of the gall bladder is related to the anterior wall of the first part of the duodenum; on the right the gall bladder is in relation with the right flexure of the colon.

The gall bladder is often connected to the duodenum or colon by a peritoneal fold.

The gall bladder is supplied with blood by the cystic artery *(arteria cystica)* which is a branch of the proper hepatic artery.

THE BILIARY DUCTS

There are three **biliary ducts** (extrahepatic bile channels) *(vasa bilifera)* (Fig. 468): the common hepatic duct *(ductus hepaticus communis)*, the cystic duct *(ductus cysticus)*, and the bile duct *(ductus choledochus)*.

The **common hepatic duct** *(ductus hepaticus communis)* forms in the porta hepatis from union of the **right** and **left hepatic ducts** *(ductus hepaticus dexter* et *ductus hepaticus sinister)*. The right hepatic duct forms from union of the anterior and posterior ducts; the left hepatic duct forms from union of the lateral and medial ducts as well as the duct of the caudate lobe *(ductus lobi caudati)*. These three ducts drain the intraorganic bile ductules *(ductuli biliferi)* and interlobular ducts *(ductuli interlobulares)*. On descending as a component of the hepatoduodenal ligament, the common hepatic duct unites with the cystic duct extending from the gall bladder; as a result the bile duct *(ductus choledochus)* forms. The common hepatic duct is 4–5 cm long and 4–5 mm in diameter. Its mucous membrane is smooth and forms no folds.

470. *Gland of bile duct* (specimen prepared by Ya. Sinelnikov). (Photomicrograph.)

(Gland isolated from completely stained wall of the bile duct.)

The **cystic duct** *(ductus cysticus)* is 3 cm in length and 3 mm in diameter. The neck of the gall bladder forms two flexures, one with the body and the other with the cystic duct (a bird's beak). After this the duct, as a component of the hepatoduodenal ligament, descends from the right slightly to the left to unite with the common hepatic duct, usually at an acute angle. The muscular coat of the cystic duct is poorly developed though it consists of two layers, a longitudinal and a circular one. For the distance of the cystic duct its mucous coat forms a fold of several spirals, this is the **spiral valve** *(plica spiralis)*.

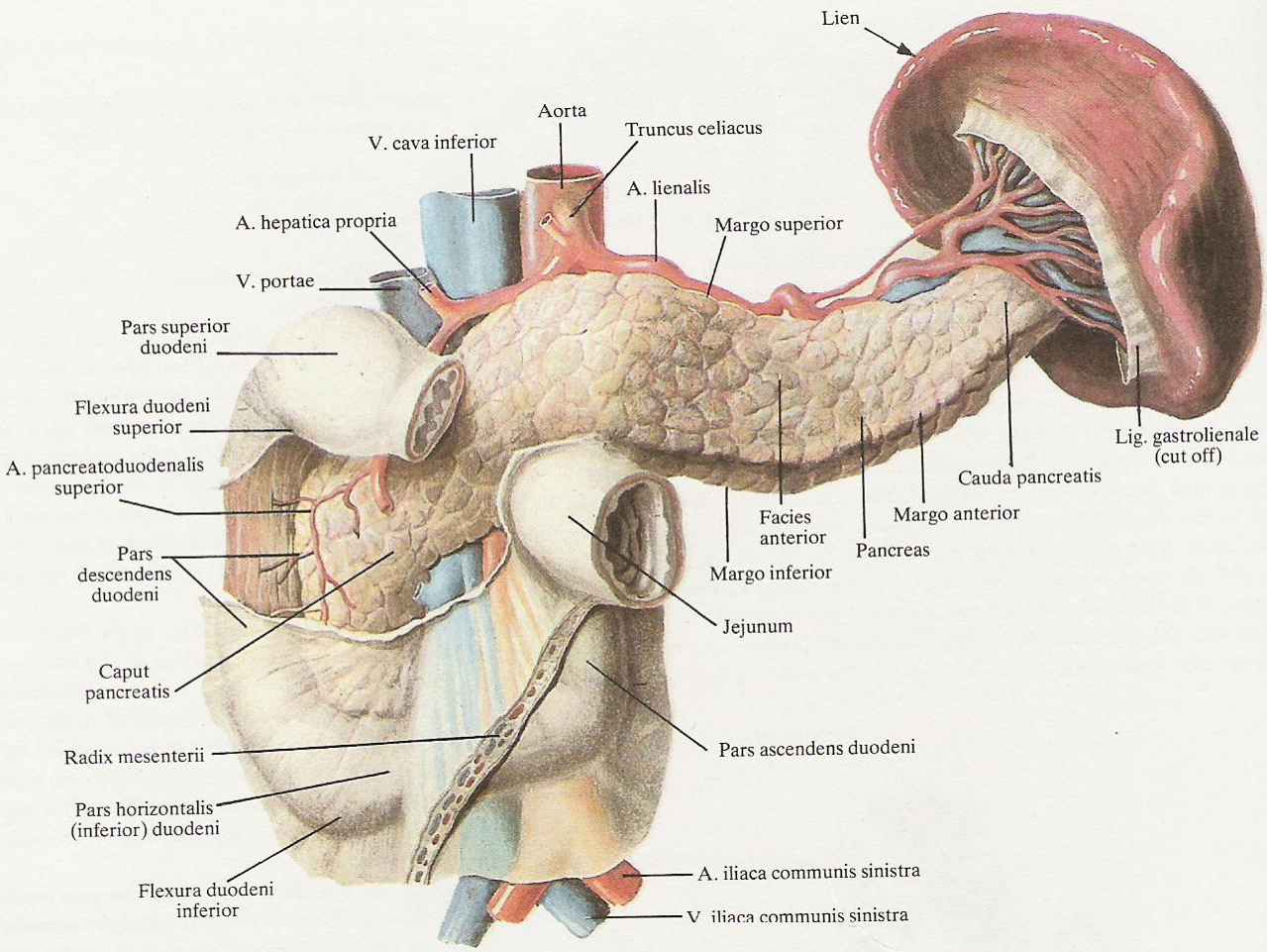
The **bile duct** *(ductus choledochus)* is embedded in the hepatoduodenal ligament. In direction it is a continuation of the common hepatic duct. On average it is 7–8 cm long, but may sometimes measure up to 12 cm. Four segments are distinguished in the bile duct: (1) a segment above the duodenum; (2) a segment behind the first part of the duodenum; (3) a segment lodged between the head of the pancreas and the wall of the descending colon; (4) a segment which adjoins the head of the pancreas and passes obliquely across it to the duodenal wall.

The last segment of the bile duct unites with the pancreatic duct to drain into a common dilatation which is called the **ampulla of the bile duct** *(ampulla hepatopancreatica)*. This ampulla opens into the second part of the duodenum at the apex of the greater duodenal papilla *(papilla duodeni major)* 15 cm from the pylorus. The ampulla may reach 5 × 12 mm in size.

The manner in which the ducts drain into the duodenum varies: they may open into it separately or one of them may drain into another.

The openings of the ducts in the region of the greater duodenal papilla are surrounded by a muscle called the **sphincter of the ampulla of the bile duct** *(musculus sphincter ampullae hepatopancreaticae)* (Fig. 468). In contrast to the walls of the common hepatic and cystic ducts, the wall of the bile duct has a stronger muscular coat forming two layers. The mucous coat of the bile duct forms no valves, with the exception of the distal segment in which there are a few folds. The submucous coat of the extrahepatic biliary ducts contains **mucous bile glands** *(glandulae mucosae biliosae)*.

Topography of the biliary ducts. The extrahepatic ducts are embedded in the duplicature of the hepatoduodenal ligament together with the hepatic artery and its branches and the portal vein. The bile duct is at the right border of the ligament, to the left of the duct is the hepatic artery, and deeper and between them is the portal vein; besides, lymph vessels, glands, and nerves lie between the layers of the ligament.



471. *Pancreas, duodenum, and spleen (lien);* anterior aspect ($^2/_3$).

The proper hepatic artery separates into the right and left hepatic arteries in the middle of the length of the ligament. The right hepatic artery *(arteria hepatica dextra)* passes upwards and under the common hepatic duct where it gives off the cystic artery *(arteria cystica)* which runs to the right and upwards into the region of the angle (space) formed from union of the cystic duct with the common hepatic duct, and stretches on the wall of the gall bladder.

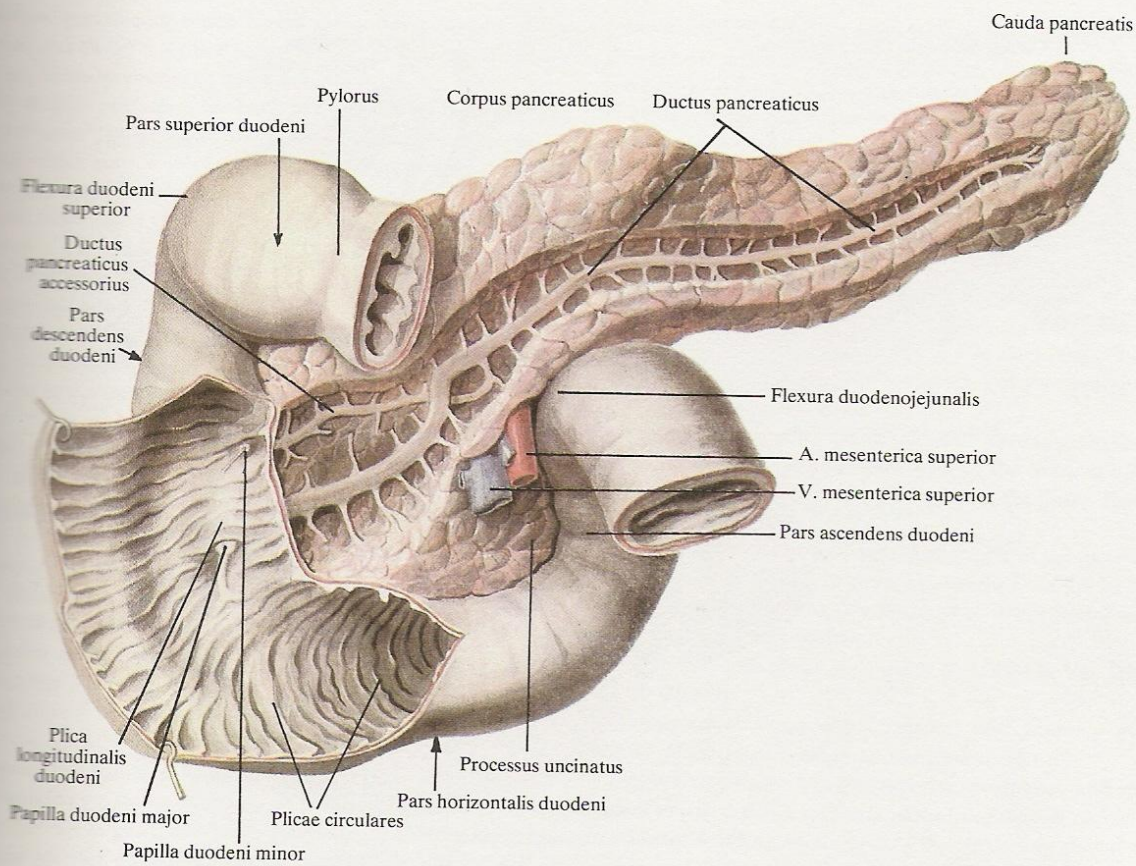
Innervation: the liver, gall bladder, and biliary ducts are supplied by nerves from the hepatic plexus *(plexus hepaticus)* [the sympathetic trunk *(truncus sympathicus)*, vagus nerve *(nervus vagus)*, phrenic nerve *(nervus phrenicus)*].

Blood supply: the common hepatic artery *(arteria hepatica communis)*.

THE PANCREAS

The **pancreas** (Figs 471–473, 479, 480) is a large digestive gland situated behind the stomach on the posterior abdominal wall on the level of the lower thoracic (eleventh, twelfth) and upper lumbar (first, second) vertebrae. Its long axis lies almost transversely crossing the vertebral column in front; one-third of the gland is to the right and two-thirds to the left of the midplane, i.e. to the right of the vertebral column (in the duodenal curve) in the epigastric and left hypochondriac regions.

The pancreas is projected on the abdominal wall 5–10 cm above the umbilicus.



472. *Pancreas and duodenum;* anterior aspect ($^2/_3$).

(The pancreatic ducts are separated in the gland; the anterior wall of part of the duodenum is cut open.)

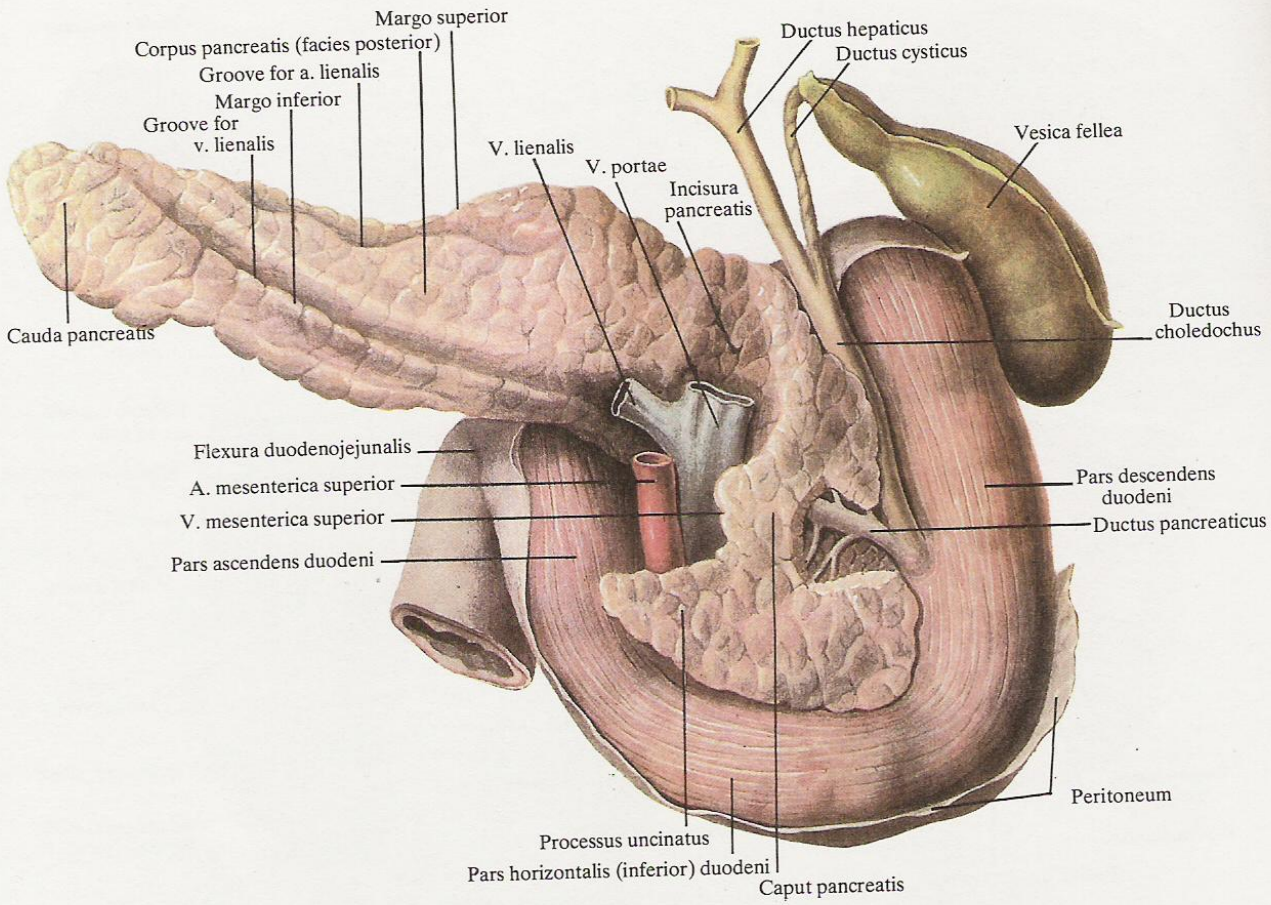
The pancreas is composed of three parts arranged next to one another from right to left: a head *(caput pancreatis)*, a body *(corpus pancreatis)*, and a tail *(cauda pancreatis)*. Between the head and body is a small narrow part, the neck.

The pancreas has an anterior and a posterior surface; in the body are also distinguished an inferior surface and three borders: anterior, superior, and inferior.

The length of the gland varies from 16 to 22 cm, its width—from 3 to 9 cm (in the region of the head), its thickness—from 2 to 3 cm, and weight—from 70 to 80 g. The pancreas has the appearance of a lobulated organ and is greyish-pink resembling the salivary parotid gland in colour. It is shaped like a horizontally placed letter S whose right part (the head) is on a lower level, that of the first and second lumbar vertebrae, while the middle (body) and the left (tail) parts ascend obliquely to the left so that the tail is in the left hypochondriac region, on the level of the eleventh and twelfth ribs.

The **head of the pancreas** *(caput pancreatis)* is situated to the right of the first and second lumbar vertebrae. It is the widest part of the gland; its right end curves downwards to form the **uncinate process** *(processus uncinatus)* (Fig. 473) which is directed to the left. The right half of the body curves slightly upwards and forwards, the left half curves downwards, and finally, the tail is directed upwards (Fig. 471). On the inferior border of the neck is the **pancreatic notch** *(incisura pancreatis)* which sets apart the uncinate process and continues on the posterior surface of the neck as a groove stretching obliquely upwards and to the right; the groove lodges the superior mesenteric artery and the superior mesenteric vein which unites here with the splenic vein to continue upwards as the portal vein.

The head of the pancreas is in contact with the duodenum which embraces it like a horseshoe so that the first part of the duodenum lies superiorly and partly anteriorly to it, the second part embraces the right border, and the third part—the inferior border.



473. *Pancreas, duodenum, gall bladder (vesica fellea), and bile ducts (vasa bilifera);* posterior aspect ($^2/_3$).

(Part of the pancreatic duct is exposed in the head of the gland.)

The bile duct *(ductus choledochus)* descends posteriorly in the upper half of the fissure between the head of the pancreas and the second part of the duodenum and lies in contact with the substance of the gland before opening into the duodenum.

Posteriorly the head of the pancreas is in contact with the right renal vein, the renal artery, and the inferior vena cava. The left border of the uncinate process in the region of the neck is in relation with the right crus of the diaphragm and the abdominal aorta.

The anterior surface of the head of the pancreas is covered by the parietal peritoneum; it is crossed in the middle by the root of the transverse mesocolon as a result of which the upper part of the head protrudes into the lesser sac of the peritoneum *(bursa omentalis)*; it is separated by the peritoneum from the posterior surface of the stomach (pyloric portion). The lower part of the head which is covered by the peritoneum, just like the adjoining third part of the duodenum, is below the root of the transverse mesocolon and is directed into the right sinus of the lower storey of the abdominal cavity where the loops of the small intestine lie next to it.

The neck of the pancreas adjoins on the right the duodenojejunal flexure; the superior mesenteric vessels emerge from under its inferior border in the region of the pancreatic notch.

The **body of the pancreas** *(corpus pancreatis)* is on the level of the first lumbar vertebra. It is prismatic in shape and has three surfaces (anterior, posterior, and inferior) and three borders (superior, anterior, and inferior). The **anterior surface** *(facies anterior corporis pancreatis)* faces to the front and slightly upwards; it is bounded inferiorly by the **anterior border** *(margo anterior corporis pancreatis)* and superiorly by the **superior border** *(margo superior corporis pancreatis)*. The **posterior surface** *(facies posterior corporis pancreatis)* faces to the back; it is bounded by the superior and inferior borders. The narrow **inferior surface** *(facies inferior corporis pancreatis)* faces downwards and is bounded by the anterior and inferior borders.

The root of the transverse mesocolon and the layers of the greater omentum *(omentum majus)* which are fused with it are attached to the anterior border of the body of the pancreas. Superiorly, along the anterior border the upper layer is continuous with

the parietal peritoneum which covers the anterior surface of the pancreas and thus forms the lining for the posterior wall of the lesser sac of the peritoneum *(bursa omentalis)*.

The anterior surface of the body of the pancreas faces the posterior surface of the stomach. The right, adjoining the neck part of the body which is in front of the vertebral column (second lumbar vertebra), projects to the front and upwards to form the **tuber omentale** *(tuber omentale pancreatis)*; it is on the level of the lesser curvature of the stomach, faces the lesser omentum, and comes in contact here with the tuber omentalis of the left lobe of the liver *(tuber omentale hepatis)*.

The posterior surface of the body of the gland is in relation with the abdominal aorta, the coeliac plexus, and the left renal vein; more to the left, the body of the gland is related to the left suprarenal gland and the left kidney. The posterior surface of the gland bears grooves lodging the splenic artery and below it, immediately under the superior border close to the middle of the posterior surface—the splenic vein.

The inferior surface of the pancreas is below the root of the transverse mesocolon. In the middle it is in relation with the hepatojejunal flexure. To the left, the inferior surface is in contact with the loops of the small intestine and an area of the transverse colon. The inferior surface is separated from the posterior surface by a blunt inferior border. The anterior surface is separated from the posterior surface by a sharp superior border on which the splenic artery runs. A peritoneal fold containing the left gastric artery stretches in the region of the tuber omentale from the superior border towards the lesser curvature of the stomach.

The **tail of the pancreas** *(cauda pancreatis)* is directed upwards and to the left and, departing from the posterior abdominal wall, it passes between the layers of the gastrosplenic ligament *(ligamentum gastrolienale)*; the splenic vessels by-pass the superior border of the gland here and stretch in front of it. The tail of the pancreas reaches the medial surface of the spleen with which its end comes in contact below and to the back of the hilus. Inferiorly, it is in relation with the left (splenic) flexure of the colon.

The **pancreatic duct** *(ductus pancreaticus)* (see Fig. 472) stretches from the tail to the head in the tissue of the gland in the middle of the distance between the superior and anterior borders, closer to the posterior than to the anterior surface. For its whole length it receives secondary ducts from the surrounding lobes of the gland. On reaching the right border of the head, the duct unites with the bile duct to form the **ampulla of the bile duct** *(ampulla hepatopancreatica)* in which they open on the apex of the greater duodenal papilla *(papilla duodeni major)*.

A second, **accessory pancreatic duct** *(ductus pancreticus accessorius)* is often found in the upper part of the head; it opens separately above the main duct on the apex of the lesser duodenal papilla *(papilla duodeni minor)*.

Age features of the pancreas. The length of the pancreas in the newborns varies from 3 to 6 cm, the weight from 2.5 to 3.0 g. The gland of a newborn is weakly attached to the posterior abdominal wall and is relatively mobile.

(The structure of the pancreas is described in Vol. III, *The Endocrine Glands*)

Innervation: the coeliac, hepatic, and superior mesenteric plexus *(plexus celiacus, hepaticus, mesentericus superior)*.

Blood supply: the hepatic, superior mesenteric, and splenic arteries (*arteriae hepatica communis, mesenterica superior* et *lienalis*).

The spleen *(lien)* is an organ of the circulatory (blood-vascular) system and is therefore described in the respective section of this volume.

THE PERITONEUM

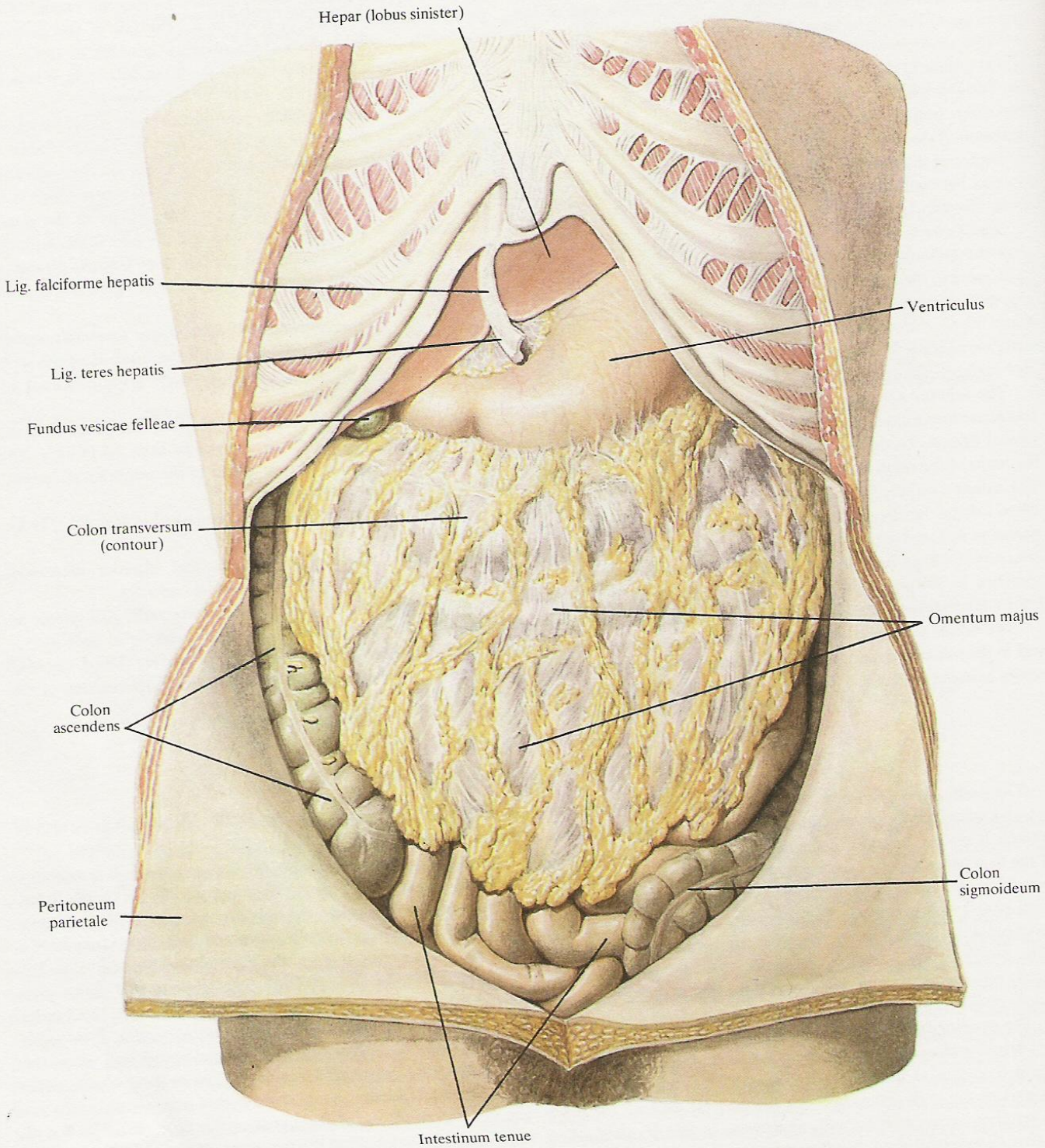
The **peritoneum** (Figs 474–483) is a thin serous membrane of the abdominal cavity which has a smooth, bright homogeneous surface. It covers the walls of the cavity of the abdomen and that of the true pelvis and to a certain extent the free, facing them surfaces of organs invested in it. The surface of the peritoneum measures 20 400 cm^2 on average and is equal to that of the skin. The peritoneum is marked by a complex microscopic structure. Its main elements are a connective-tissue basis formed of many strictly oriented layers of a certain structure and an overlying layer of mesothelial cells.

The peritoneum which lines the walls of the abdomen is called the **parietal peritoneum** *(peritoneum parietale)*, and that covering the organs is known as the **visceral peritoneum** *(peritoneum viscerale)*; the part of the peritoneum between the parietal peritoneum and the serous covering of the organs or between organs is called a **ligament** *(ligamentum)*, **fold** *(plica)*, or **mesentery** *(mesenterium)*.

The visceral peritoneum of any organ is connected with the parietal peritoneum as the result of which all organs are fastened by the peritoneum to the walls of the abdominal cavity to this or that degree. Most organs are connected with the posterior wall of the abdominal cavity.

An organ completely covered by the peritoneum is intraperitoneal; one covered on three surfaces and not on the fourth is mesoperitoneal; an organ covered only on one, outer surface is retroperitoneal (or extraperitoneal). Intraperitoneal organs may have a mesentery connecting them to the parietal peritoneum.

A mesentery is a sheet consisting of peritoneal layers connected to one another, thus forming a duplicature; the free border of the mesentery encloses the organ (intestine) and as if suspends it, while the other border passes to the abdominal wall where the layers separate to run in different directions as the parietal peritoneum. Blood and lymph vessels and nerves pass usually to the organ between the layers of the mesentery (or ligament). The line of attachment (initial part) of the mesentery to the abdominal wall is called the **root of the mesentery** *(radix mesenterii)*; on approaching an organ (e.g. the intestine) the layers of the peritoneum separate to both sides thus leaving a narrow strip at the site of attachment, which is known as the **bare area** *(area nuda)*.



474. *Organs of cavity of abdomen;* anterior aspect ($^1/_3$).

(The anterior abdominal wall is opened and removed in the upper parts, and reflected in the lower parts.)

The serous coat *(tunica serosa)* is not in direct contact with an organ or abdominal wall but is separated from them by a layer of connective tissue called extraperitoneal tissue *(tela subserosa)* which varies in the degree of development depending on the place which it occupies. For instance, it is poorly developed under the serous coat of the liver, diaphragm, and upper part of the anterior abdominal wall, but, in contrast, strongly developed under the parietal peritoneum lining the posterior wall of the abdominal cavity (subperitoneal fat), e.g. in the region of the kidneys, etc., where the peritoneum is connected very loosely with the underlying organs or with their parts by means of loose connective tissue.

Among the intraperitoneal organs are the stomach, the small intestine (except for the duodenum), the transverse and pelvic colon, the proximal segment of the rectum, the vermiform appendix, the spleen, the uterus, and the uterine tubes. The liver, the gall bladder, the ascending and descending colon, and the middle (ampullar) part of the rectum are mesoperitoneal organs. The duodenum (except for its first part), the pancreas (except for the tail), the kidneys, the suprarenal glands, and the ureters are retroperitoneal organs.

The space in the abdomen bounded by the peritoneum is called the **cavity of the peritoneum** *(cavum peritonei)*. The parietal peritoneum of the posterior abdominal wall separates the cavity of the peritoneum from the **retroperitoneal space** *(spatium retroperitoneale)*. These two spaces form the **cavity of the abdomen** *(cavum abdominis)*. Since the peritoneum forms a continuous covering both on the walls and on the organs, the cavity of the abdomen in males is closed. In females it communicates with the uterine tubes: one end of the uterine tube opens into the cavity of the peritoneum, and the other leads outside via the cavity of the uterus. The organs of the abdominal cavity are related to one another; the space between them and the walls of the abdominal cavity as well as the space between the organs themselves is slit-like and contains a very small amount of serous fluid *(liquor peritonei)*.

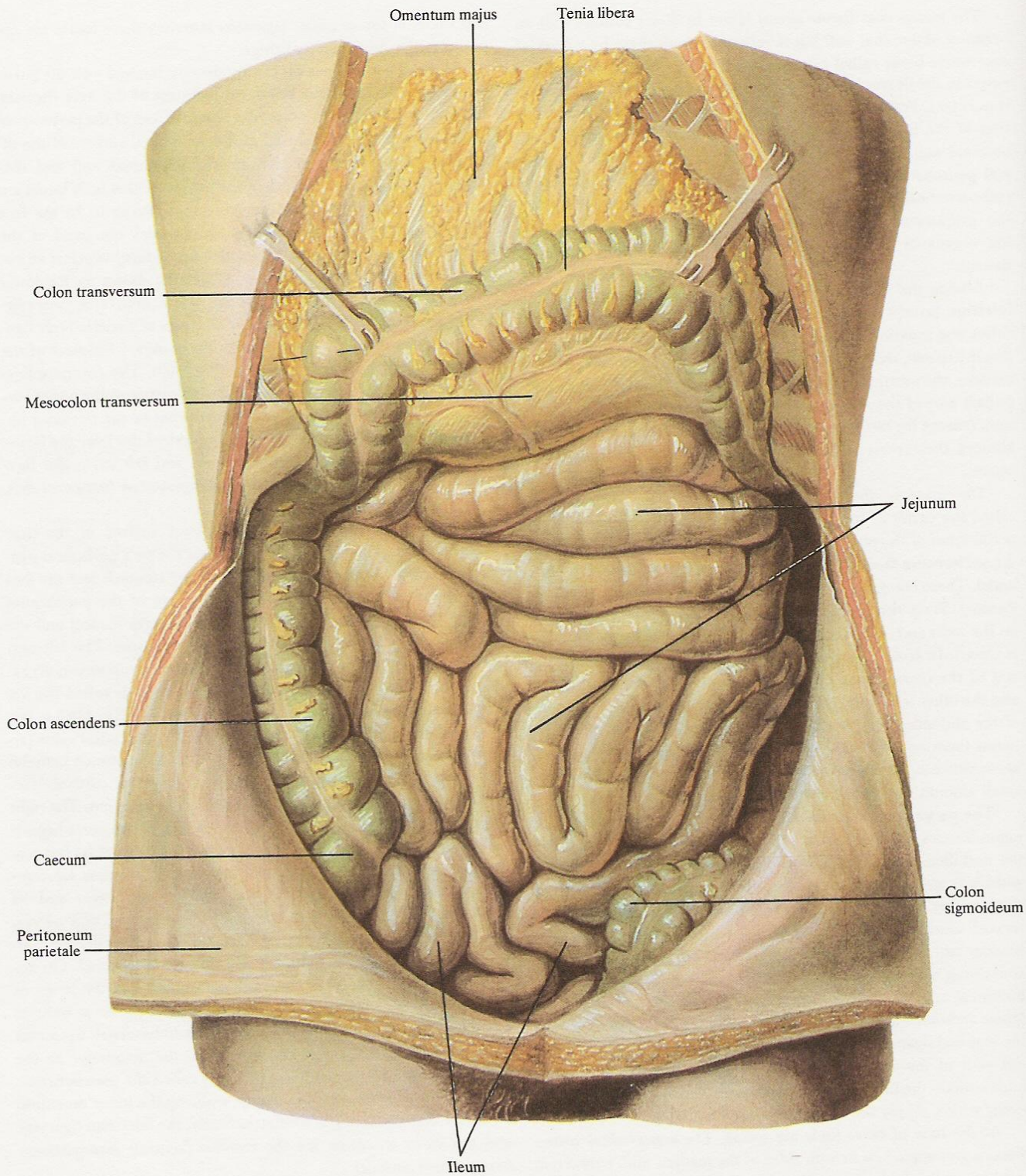
The peritoneum and the peritoneal folds. The parietal peritoneum forms a series of folds on the anterior abdominal wall. Below the umbilicus on the midline is the **median umbilical fold** *(plica umbilicalis mediana)* stretching from the umbilicus to the apex of the bladder; it contains a connective-tissue cord which is the obliterated urachus. From the umbilicus to the lateral walls of the bladder run the **medial umbilical folds** *(plicae umbilicales mediales)* containing the bands of the obliterated anterior segments of the umbilical arteries. Lateral to them are the **lateral umbilical folds** *(plicae umbilicales laterales)* (Fig. 478) stretching from the middle of the inguinal ligament obliquely upwards and medially to the posterior wall of the sheath of the rectus abdominis muscles. These folds contain the inferior epigastric arteries *(arteriae epigastricae inferiores)* which supply the rectus abdominis muscles.

At the base of these folds are fossae. The **supravesical fossae** *(fossae supravesicales)* lie to both sides of the median fold, between it and the medial fold, above the upper border of the bladder. Between the medial and lateral folds are the **middle inguinal fossae** *(fossae inguinales mediales)* and lateral to the lateral folds lie the **lateral inguinal fossae** *(fossae inguinales laterales)*; these fossae are opposite to the deep inguinal rings.

Above the umbilicus on the anterior abdominal wall the parietal peritoneum forms the **falciform ligament of the liver** *(ligamentum falciforme hepatis)*. It is a median sagittal fold of the peritoneum of the anterior abdominal wall at the abdominal surface of the diaphragm; the fold descends from the abdominal wall and diaphragm to the superior surface of the liver on which both layers are continuous with the visceral peritoneum covering it. In the free lower border of the falciform ligament passes the band of the **round ligament of the liver** *(ligamentum teres hepatis)* which is an obliterated umbilical vein. The round ligament passes on the lower surface of the liver in the fissure for the ligamentum teres *(fissura ligamenti teretis)* to the porta hepatis. The layers of the falciform ligament are continuous posteriorly with the **coronary ligament of the liver** *(ligamentum coronarium hepatis)* (Fig. 460). The coronary ligament is a continuation of the visceral peritoneum of the upper surface of the liver with the parietal peritoneum of the posterior abdominal wall. On the right and left borders of the liver the layers of the coronary ligament form the **right** and **left triangular ligaments** (*ligamentum triangulare dextrum* et *ligamentum triangulare sinistrum*).

The visceral peritoneum on the lower surface of the liver covers the gall bladder inferiorly. It gives rise to a peritoneal ligament running to the lesser curvature of the stomach and the first part of the duodenum. This is a duplicature of the peritoneum arising from the margins of the porta (transverse fissure) and the margins of the fissure for the ligamentum venosum. The left part of this ligament (from the fissure for the ligamentum venosum) extends to the lesser curvature of the stomach and is called the **hepatogastric ligament** *(ligamentum hepatogastricum)* (Fig. 476); it is a fine web-like sheet. The right and left gastric arteries and veins (*arteriae* et *venae gastricae dextra* et *sinistra*) and nerves stretch between the layers of the hepatogastric ligament on the lesser curvature; regional lymph glands are also embedded in the ligament. The right part of the ligament is thicker and stretches from the porta hepatis to the upper border of the pylorus and the duodenum; its last segment is called the **hepatoduodenal ligament** *(ligamentum hepatoduodenale)* and contains the bile duct, the hepatic artery and its branches, the portal vein, lymph vessels and glands, and nerves. On the right the hepatoduodenal ligament forms the anterior margin of the **opening into the lesser sac** *(foramen epiploicum)*. On approaching the border of the stomach and duodenum, the layers of the ligament separate to cover the anterior and posterior walls of these organs. The hepatogastric and hepatoduodenal ligaments and also a small ligament stretching from the diaphragm to the lesser curvature of the stomach, which is called the **gastrophrenic ligament** *(ligamentum gastrophrenicum)*, make up the **lesser omentum** *(omentum minus)* (Fig. 476). Ontogenetically, the falciform ligament and the lesser omentum are the anterior (ventral) mesogastrium *(mesogastrium ventrale)*.

The peritoneum forms a fold between the lower border of the right lobe of the liver and the upper end of the right kidney; this is the **hepatorenal ligament** *(ligamentum hepatorenale)*.



475. *Organs of cavity of abdomen;* anterior aspect ($^1/_3$).

[The greater omentum *(omentum majus)* and the transverse colon are pulled upwards.]

The layers of the visceral peritoneum on the anterior and posterior surfaces of the stomach are continuous with the gastrocolic ligament *(ligamentum gastrocolicum)* along the greater curvature of the stomach and stretch downwards as the **greater omentum** *(omentum majus)*. The greater omentum (Figs 474, 482, 483) hangs as a wide sheet ('apron') down to the level of the inlet of the pelvis. Here the two layers forming it return upwards behind the descending two layers and fuse with them. At the level of the transverse colon the four layers fuse with the taenia omentalis *(tenia omentalis)* stretching on the anterior surface of the intestine. Here the posterior (returning) layers of the omentum separate from the anterior layers to join the **transverse mesocolon** *(mesocolon transversum)* and together with it pass dorsally to the line of attachment of the mesentery on the posterior abdominal wall to the anterior border of the body of the pancreas.

As a result a sac (recess) forms between the anterior and posterior layers of the omentum on the level of the transverse colon (see below). On approaching the anterior border of the body of the pancreas, the posterior two layers of the omentum separate: the superior layer is continuous with the posterior wall of the lesser sac of the peritoneum (on the surface of the pancreas) as the parietal peritoneum, the inferior layer continues as the upper layer of the transverse mesocolon (Figs 482, 483).

The part of the greater omentum between the greater curvature of the stomach and the transverse colon is called the **gastrocolic ligament** *(ligamentum gastrocolicum)*; it attaches the transverse colon to the greater curvature of the stomach. The right and left gastro-epiploic arteries and veins run along the greater curvature of the stomach between the layers of the gastrocolic ligament, and regional lymph glands are situated here. The gastrocolic ligament covers the transverse colon anteriorly; in order to expose the colon when the abdominal cavity is opened the greater omentum must be pulled upwards. The greater omentum covers the small and large intestine in front and is behind the anterior abdominal wall. A narrow slit forms between the omentum and the anterior abdominal wall. The greater omentum is an extended mesentery of the stomach, the mesogastrium. It continues to the left as the gastrosplenic ligament *(ligamentum gastrolienale)* and the **lienorenal ligament** *(ligamentum phrenicolienale)* which are continuous with one another (Figs 476, 479, 480). The anterior peritoneal layer of the gastrosplenic ligament passes over to the spleen, surrounds it completely, returns to the hilum of the organ, and continues as the layer of the lienorenal ligament *(ligamentum phrenicolienale)*.

The posterior layer of the gastrosplenic ligament approaches the hilum of the spleen and turns directly towards the posterior abdominal wall as the second layer of the lienorenal ligament. As a result the spleen is enclosed laterally in a ligament connecting the greater curvature of the stomach with the diaphragm.

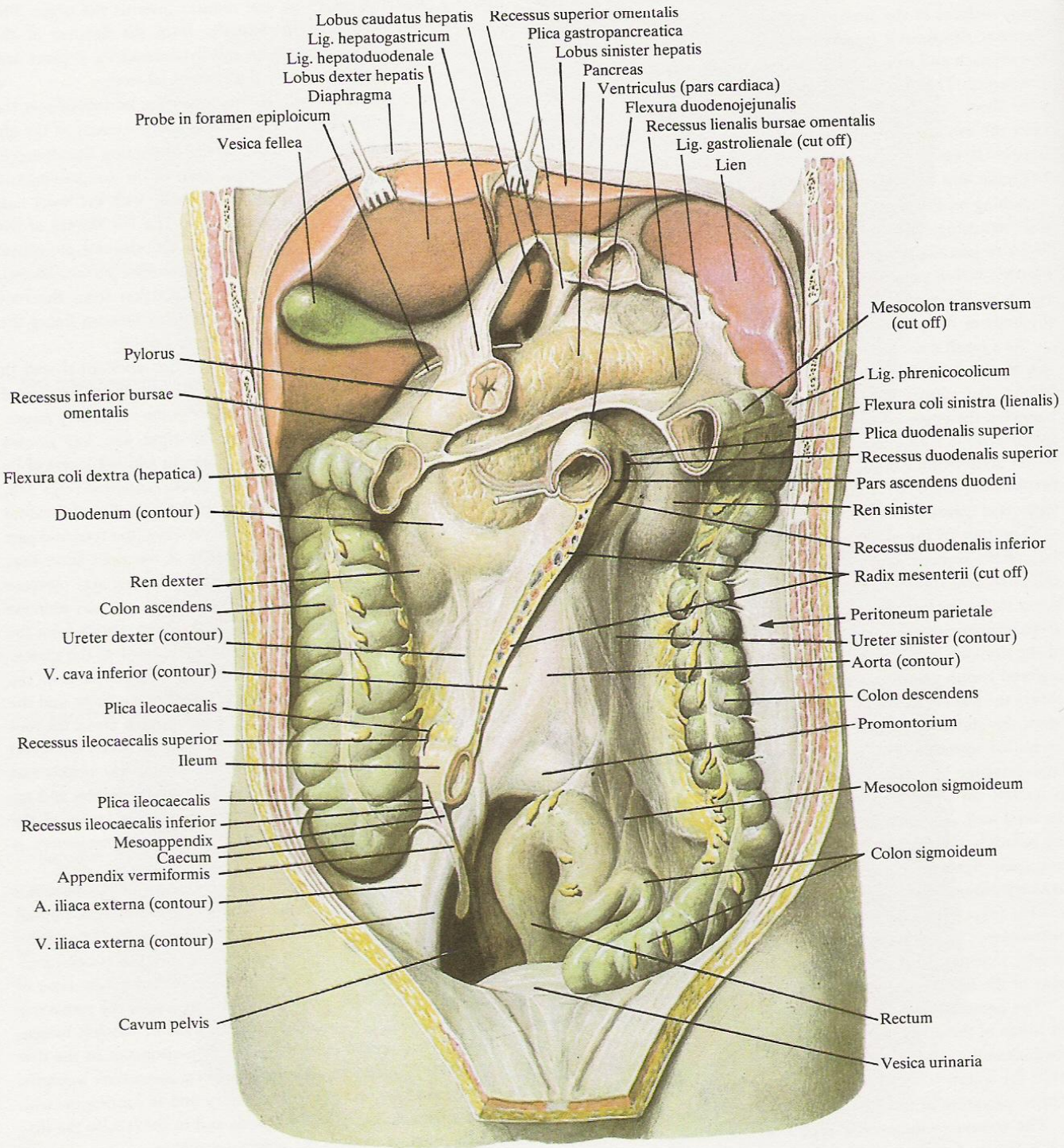
The transverse mesocolon begins on the posterior abdominal wall at the level of the second part of the duodenum, the head and body of the pancreas, and the left kidney. On approaching the colon the two layers of the mesocolon separate at the taenia mesocolica and surround the intestine (see *The Colon*). The width of the transverse mesocolon from the root to the attachment to the intestine is a maximum of 15 cm and reduces towards the edges. The transverse mesocolon begins laterally from the flexures of the colon *(flexurae colicae)* situated in the hypochondriac regions and extends for the whole width of the abdominal cavity.

The transverse colon with its mesentery lies horizontally at the level of the ends of the tenth ribs and divides the cavity of the abdomen into two storeys: an upper storey containing the stomach, liver, spleen, pancreas, and the upper parts of the duodenum, and a lower storey occupied by the small intestine with the lower half of the duodenum and the large intestine. The left flexure of the colon is connected to the diaphragm by a horizontal peritoneal fold called the **phrenicocolic ligament** *(ligamentum phrenicocolicum)*. The posterior layer of the transverse mesocolon from the root downwards is continuous with the parietal peritoneum lining the posterior wall of the abdominal mesenteric sinuses.

The peritoneum which lines the posterior abdominal wall in the lower storey is continuous in the middle with the mesentery of the small intestine, commonly referred to as the **mesentery** *(mesenterium)*. The parietal peritoneum of the right and left sinuses passes over to the mesentery to form the right and left layers of its duplicature. The **root of the mesentery** *(radix mesenterii)* (Figs 476, 477, 480, 482) descends from the left of the posterior abdominal wall in the region of the second lumbar vertebra (the terminal part of the duodenojejunal fold) to the region of the right sacro-iliac joint (the ileocaecal junction). The length of the root may measure up to 17 cm, the width of the mesentery is 15 cm but may increase in segments of the small intestine which are most remote from the posterior abdominal wall. Along its course the root of the mesentery crosses the fourth part of the duodenum, then the aorta on the level of the fourth lumbar vertebra, the inferior vena cava, and the right ureter. The superior mesenteric vessels stretch along the root of the mesentery downwards from left to right. Between the layers of the mesentery branches arise from the mesenteric vessels and pass to the walls of the intestine. Lymph vessels, nerves, and regional lymph glands are also situated between the layers of the mesentery. As a result the duplicated sheet of the mesentery is dense and thick.

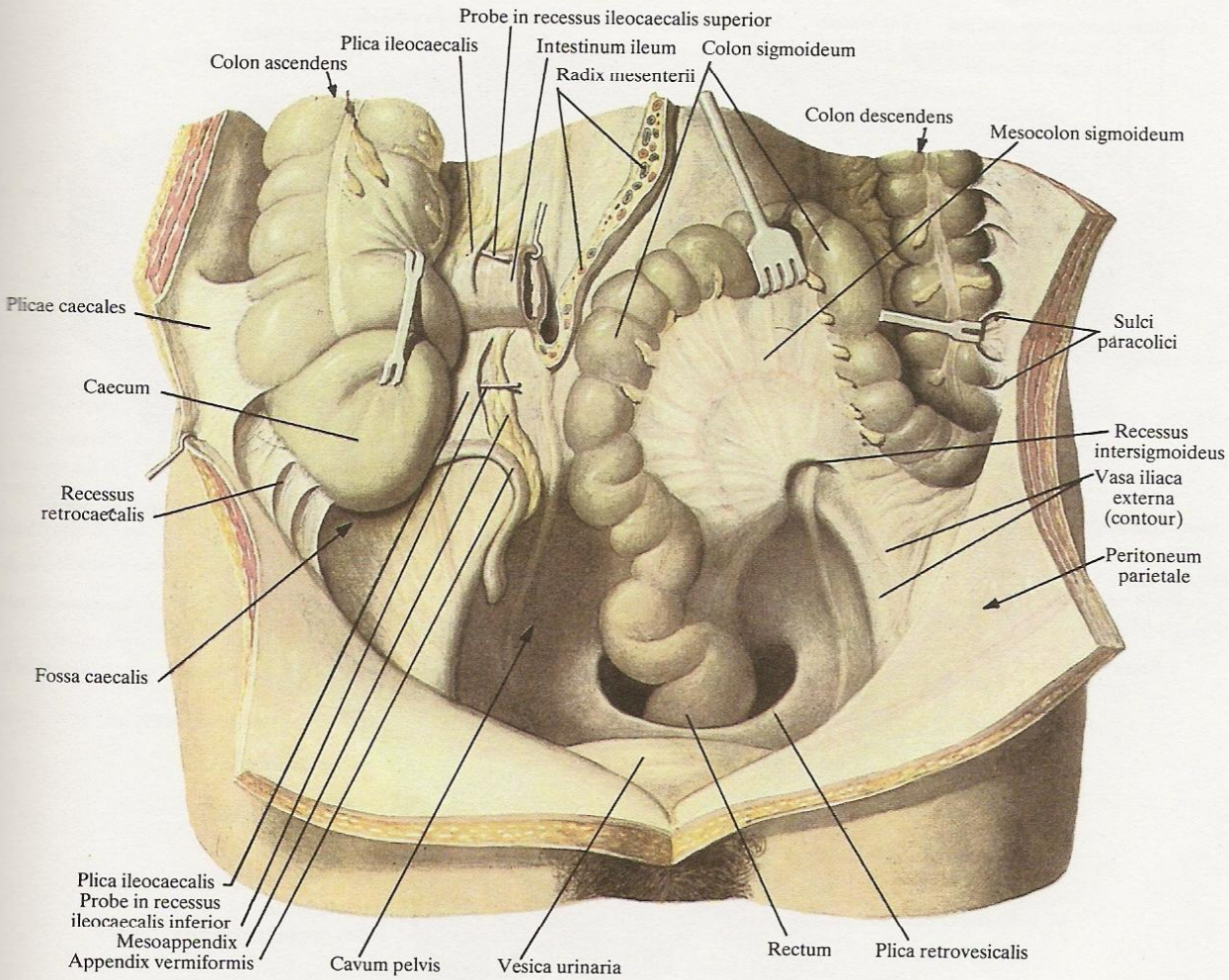
Thus, the mesentery divides the peritoneum of the posterior wall of the abdominal cavity into two areas called the **right** and **left mesenteric sinuses** (*sinus mesenterici dexter* et *sinister*). The parietal peritoneum of the right sinus is continuous with the visceral peritoneum of the ascending colon to the right, with the right layer of the mesentery to the left and downwards, and with the transverse mesocolon upwards. The parietal peritoneum of the left mesenteric sinus is continuous with the visceral peritoneum of the descending colon to the left, with the transverse mesocolon upwards; downwards it bends over the promontory and is continuous with the pelvic peritoneum; and downwards and to the left, in the iliac fossa, it is continuous with the pelvic mesocolon.

On the right the peritoneum covers the ascending colon on three surfaces, lines to the right of it the posterior and lateral abdominal walls to form the **right lateral canal** *(canalis lateralis dexter)*, passes anteriorly to be continuous with the parietal peritoneum of the anterior abdominal wall; upwards, with the peritoneum of the



476. *Organs of cavity of abdomen;* anterior aspect ($^1/_3$).

(The stomach, mesenterial intestine, and part of the transverse colon are removed; the liver is pulled upwards.)



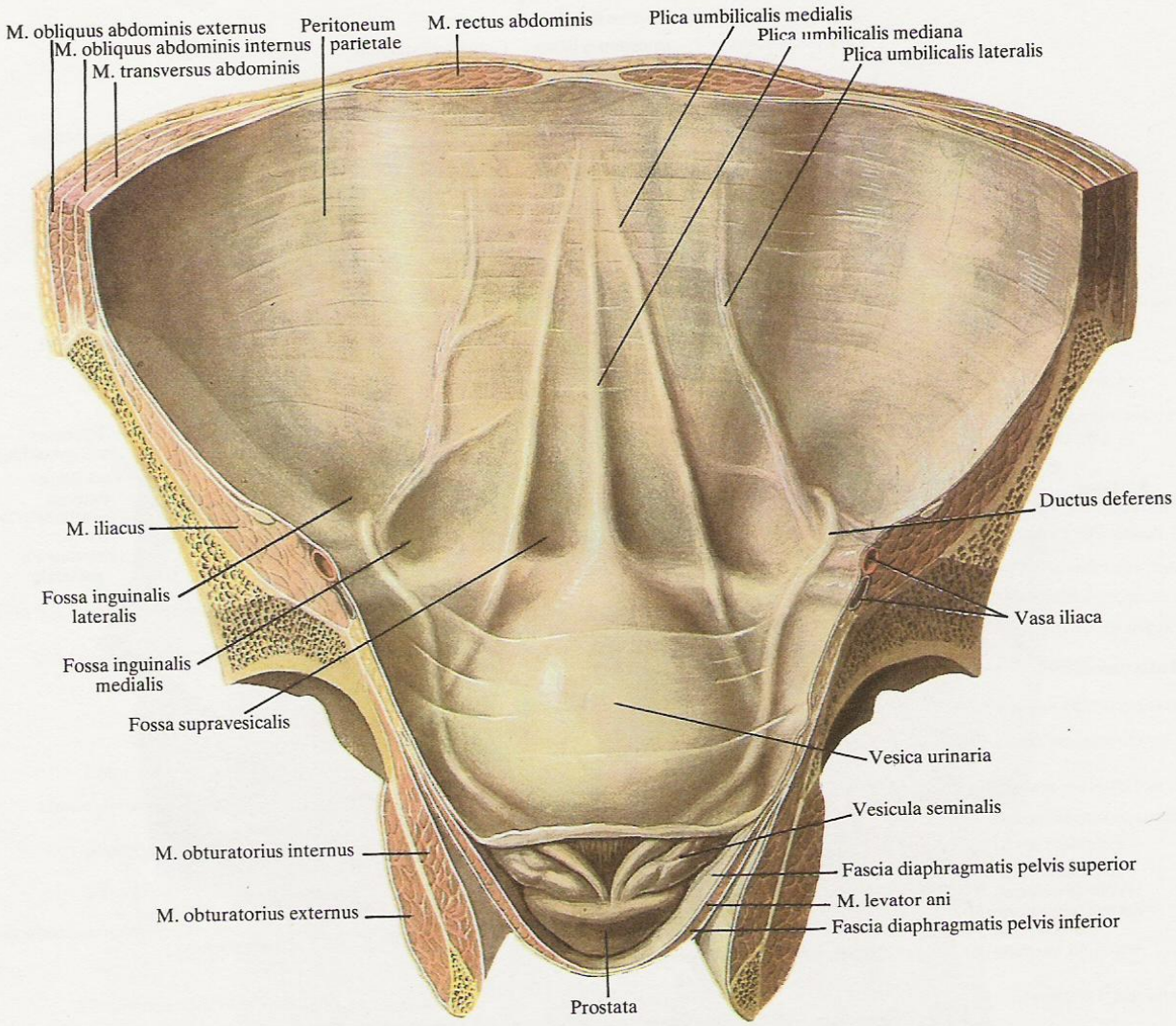
477. *Organs of lower part of abdominal cavity;* anterior aspect ($^2/_5$).

(The caecum and pelvic colon are pulled upwards.)

right part of the diaphragm; downwards it is continuous with the peritoneum of the right iliac fossa and, below the caecum in the region of the inguinal fold, passes onto the anterior abdominal wall; medially it curves over the arcuate line into the true pelvis. To the right of the ascending colon the peritoneum forms transverse folds which connect superiorly the right flexure of the colon *(flexura coli dextra)* with the lateral abdominal wall, and forms also the right phrenicocolic ligament which is usually poorly developed or not at all.

The **ileocaecal fold** *(plica ileocaecalis)* (Figs 476, 477) forms at the junction of the small intestine with the caecum. It streches between the medial wall of the caecum, the anterior wall of the ileum, and the parietal peritoneum and also connects the medial wall of the caecum with the inferior wall of the ileum superiorly, and with the base of the vermiform appendix inferiorly. Between the upper border of the vermiform appendix, the ileum, and the wall of the medial area of the fundus of the caecum is the **mesentery of the vermiform appendix** *(mesoappendix)*. It contains the appendicular artery and vein (*arteria appendicularis* et *vena appendicularis*), regional lymph glands, and nerves. The **caecal folds** *(plicae cecales)* (Fig. 477) stretch between the lateral area of the fundus of the caecum and the parietal peritoneum of the iliac fossa.

The parietal peritoneum of the left mesenteric sinus is continuous to the right with the left layer of the mesentery. In the region of the duodenojejunal flexure *(flexura duodenojejunalis)* the parietal peritoneum forms a fold which loops the beginning of the jejunum superiorly and on the left; this is the **superior duodenal fold**, or **duodenojejunal fold** (*plica duodenalis superior* s. *plica duodenojejuna-*

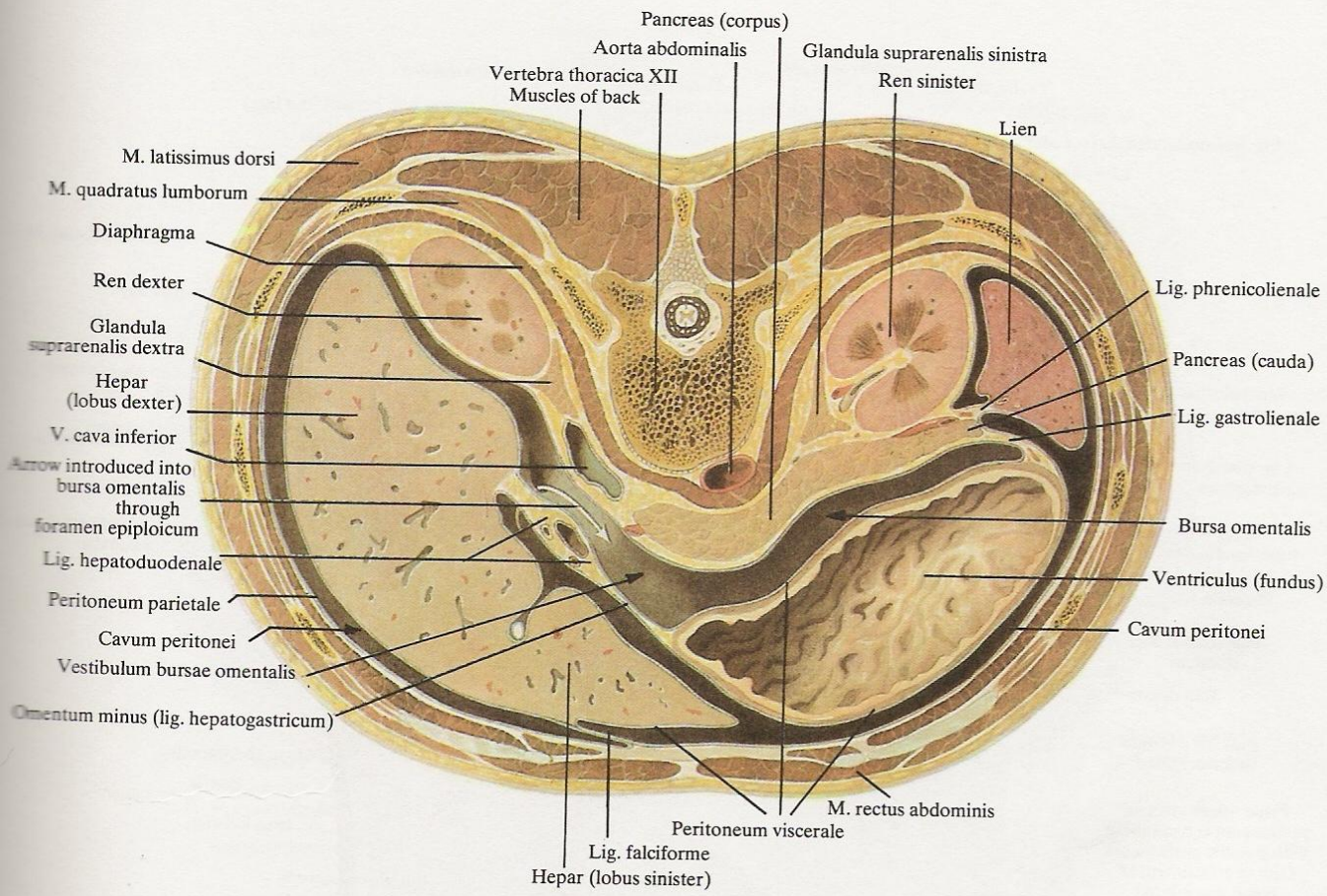


478. *Peritoneum of lower part of anterior wall of abdomen and pelvis;* inner aspect ($^1/_2$).

(Folds and fossae on the inner surface of the anterior abdominal wall.)

lis). To the left of the descending colon is a peritoneal fold connecting the left flexure of the colon with the diaphragm; it is called the **phrenicocolic ligament** *(ligamentum phrenicocolicum)* (Fig. 476) and, in contrast to its fellow on the right side, it is constant and well developed. To the left the parietal peritoneum is continuous with the visceral peritoneum covering the descending colon on three surfaces (except for the posterior surface). To the left of the descending colon the peritoneum lines the posterior and lateral walls of the cavity of the abdomen to form the **left lateral canal** *(canalis lateralis sinister)* and passes on to the anterior abdominal wall; downwards it is continuous with the parietal peritoneum of the iliac fossa and the anterior wall of the abdomen and true pelvis. In the left iliac fossa the peritoneum forms the **pelvic mesocolon** *(mesocolon sigmoideum)*. The root of this mesocolon descends to the right, to the arcuate line reaching the anterior surface of the third sacral vertebra; a short mesentery for the upper part of the rectum forms here. The inferior left colic arteries *(arteriae sigmoideae)* and inferior left colic veins *(venae sigmoideae)* enter the pelvic mesocolon; lymph vessels and nodes and nerves are also enclosed in it.

The peritoneal folds, ligaments, mesenteries, and organs produce fissures, recesses, sinuses, and bursae in the cavity of the peritoneum which are relatively isolated from one another and from the cavity of the peritoneum proper. As it is mentioned above, the cavity of the peritoneum is subdivided into three main territories:



479. *Horizontal section of trunk* ($^2/_5$).

(Section through the level of the twelfth thoracic vertebra. The peritoneum is coloured blue.)

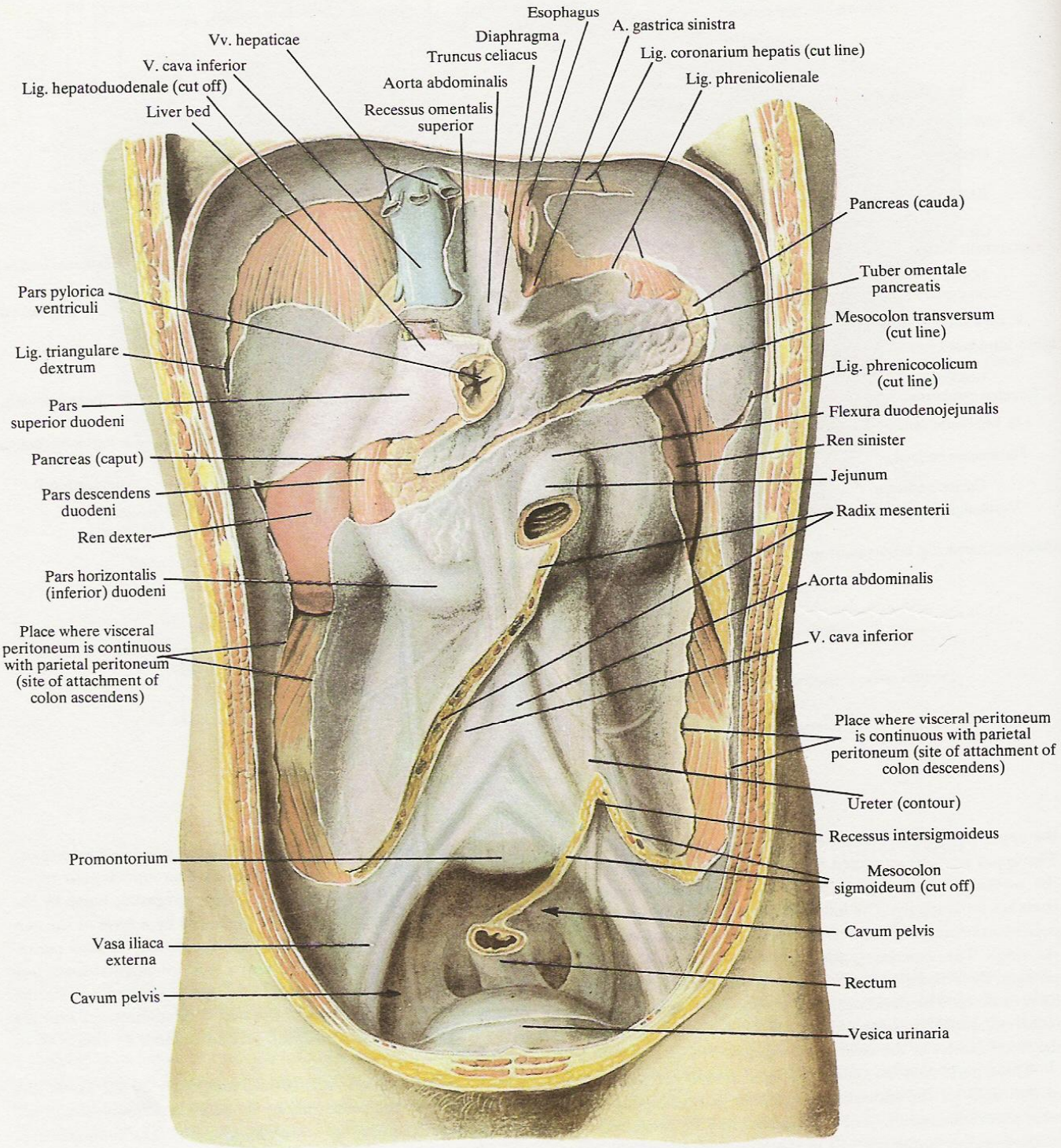
the upper storey, the lower storey, and the cavity of the true pelvis. The upper storey is separated from the lower storey on the level of the second lumbar vertebra by the transverse mesocolon which stretches horizontally. The lower storey is separated from the true pelvis by the arcuate line of the pelvis (the upper border of the pelvic ring). The superior border of the upper storey is the diaphragm, the inferior border is formed by the transverse colon with its mesentery. The peritoneal fold on the floor of the pelvis (the rectovesical fold in males and the recto-uterine fold in females) is the lower border of the cavity of the pelvis.

Three peritoneal bursae are distinguished in the upper storey of the cavity of the abdomen: the hepatic bursa situated for the most part in the right half of the upper storey; the pregastric bursa situated mainly in the left half of the upper storey, and the omental bursa, or lesser sac of the peritoneum, which is pronounced most and is situated behind the stomach.

The **hepatic bursa** *(bursa hepatica)* is a slit-like space embracing the free part of the liver. A suprahepatic and subhepatic recesses are distinguished in it (the terms subphrenic space and subhepatic space are accepted in practical medicine). The suprahepatic recess is separated on the left from the adjoining pregastric bursa by the falciform ligament; posteriorly it is bounded by a layer of the coronary ligament. It communicates with the distally located peritoneal spaces: with the subhepatic recess and pre-omental space (see below) anteriorly along the free lower border of the liver; via the free border of the right lobe of the liver it communicates with the right lateral canal, then with the iliac fossa, and, by means of it, with the true pelvis.

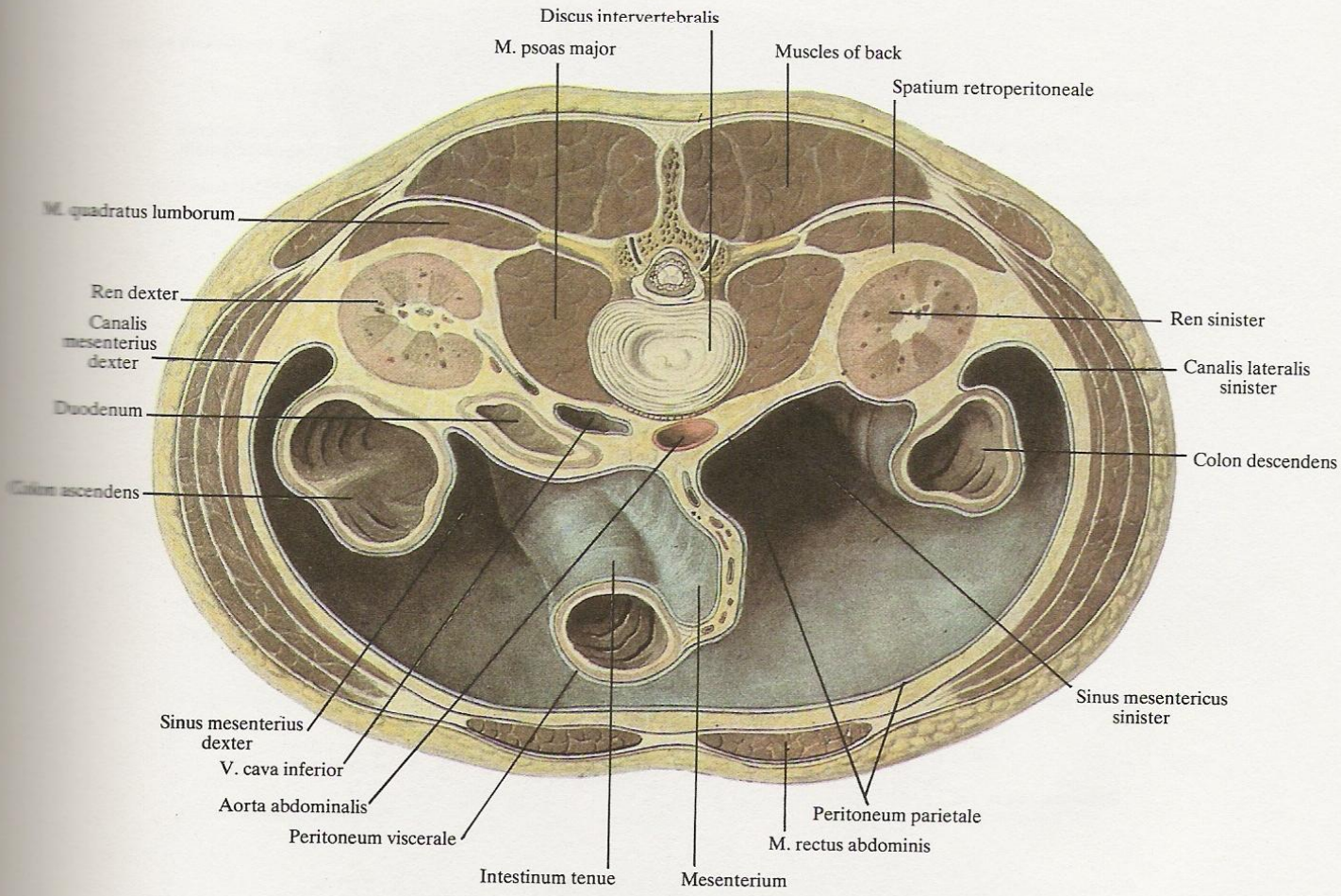
The subhepatic recess is formed superiorly by the lower surface of the liver and posteriorly by the parietal peritoneum and the hepatorenal ligament *(ligamentum hepatorenale)*. The subhepatic recess communicates laterally with the right lateral canal, anteriorly with the preomental space, on the bottom with the lesser sac of the peritoneum via the opening into it, and on the left the subhepatic fissure communicates with the pregastric bursa.

The **pregastric bursa** *(bursa pregastrica)* is situated under the left



480. *Posterior wall of cavity of abdomen;* inner aspect ($^1/_3$).

(The peritoneum is coloured blue.)



481. *Horizontal section of trunk* ($^2/_5$).

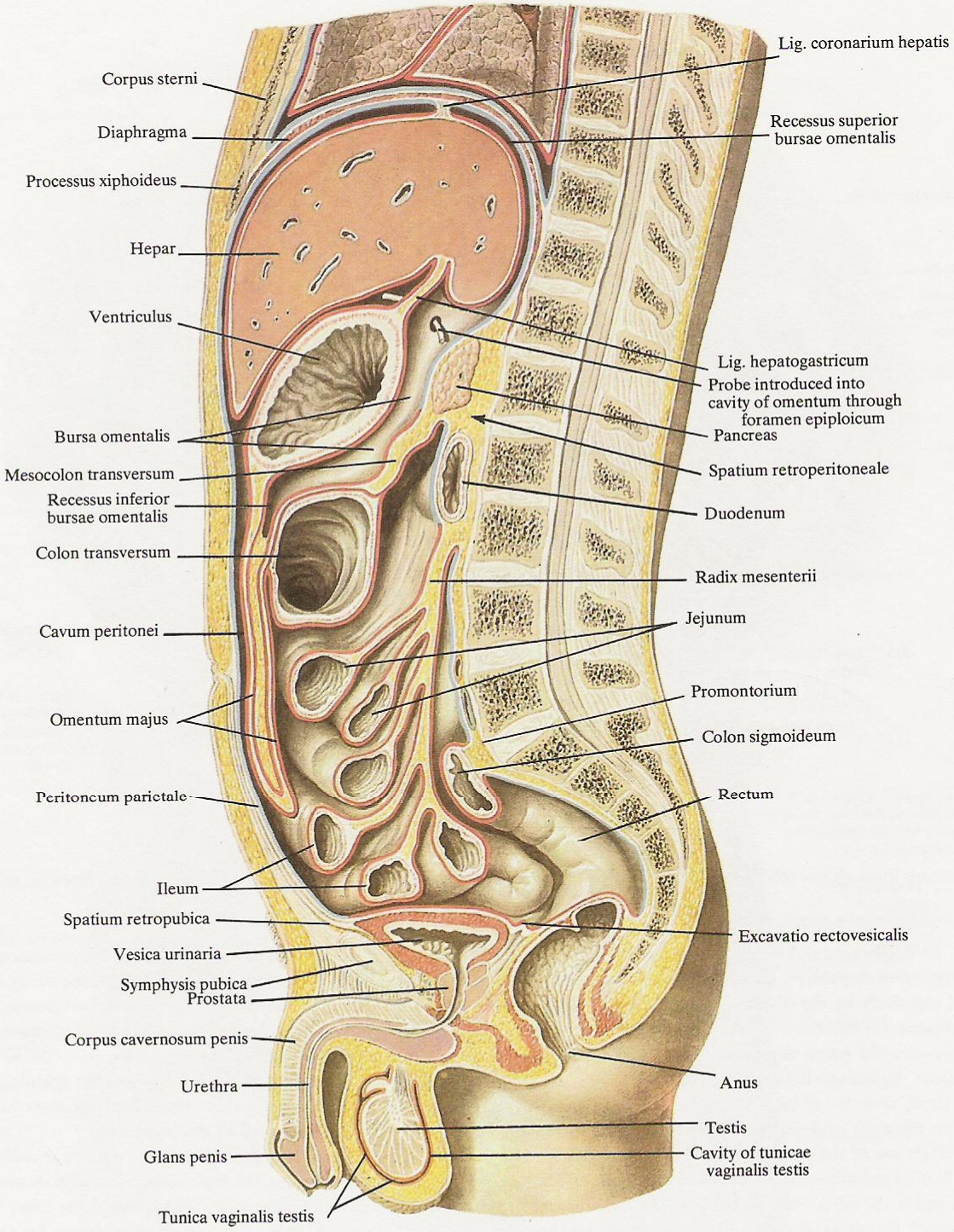
(Section through the level between the bodies of the second and third lumbar vertebrae. The peritoneum is coloured blue.)

dome of the diaphragm and curves round the left lobe of the liver on the right and the spleen on the left. The pregastric bursa is bounded superiorly by the diaphragm, on the right—by the falciform ligament, on the left—by the phrenicocolic ligament, and posteriorly—by the lesser omentum (by all three parts) and the gastrosplenic ligament. It communicates with the preomental space in front, with the subhepatic bursa and lesser sac of the peritoneum on the right, and with the left lateral canal on the left.

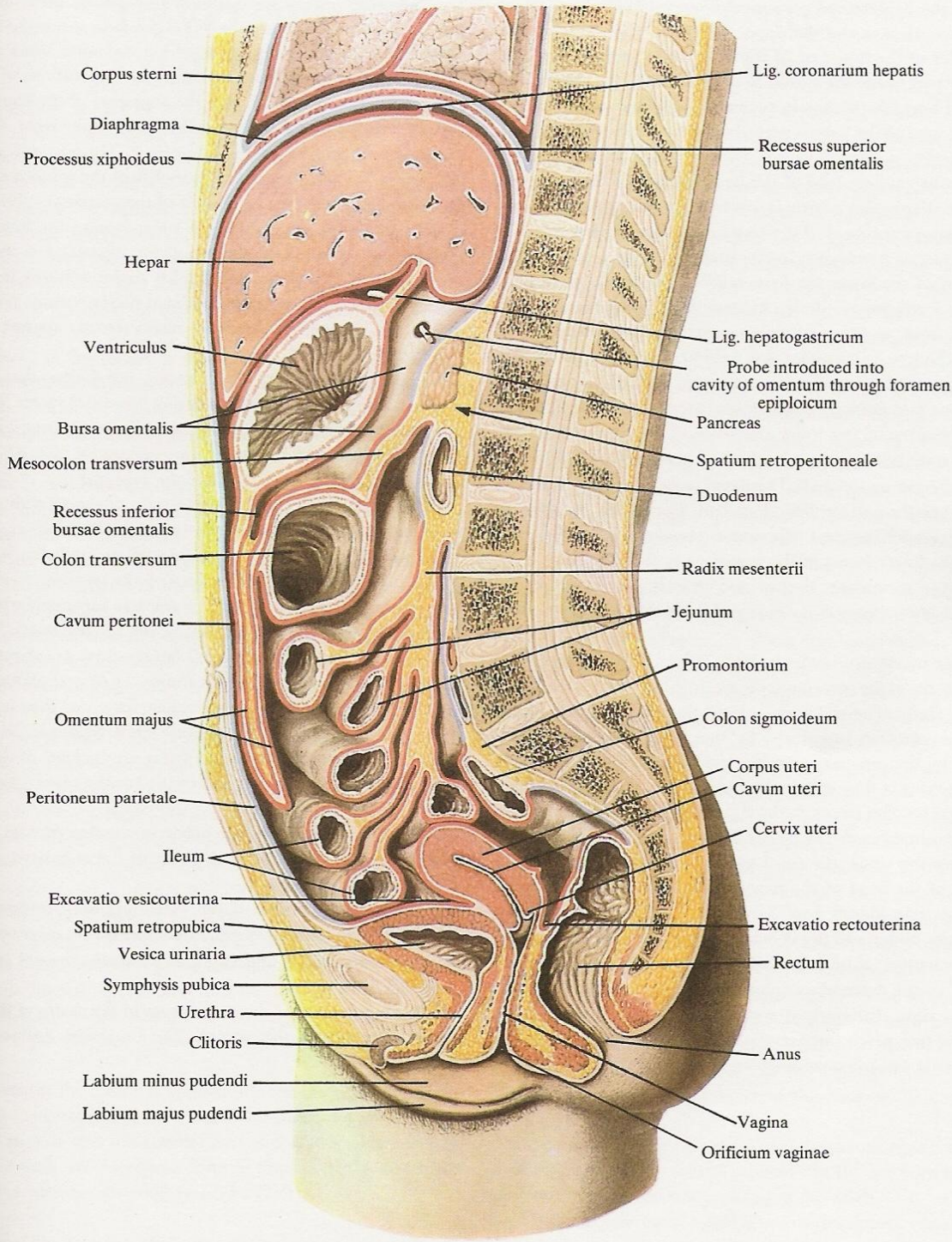
The **lesser sac of the peritoneum** *(bursa omentalis)* (Fig. 479) is situated behind the stomach. It extends to the epiploic foramen on the right and to the hilus lienis on the left. The anterior wall of the sac is formed (counting downwards) by the lesser omentum, the posterior wall of the stomach, the gastrocolic ligament, and sometimes by the upper part of the greater omentum if its ascending and descending layers are not fused and there is a slit between them which is considered a downward continuation of the lesser sac.

The posterior wall of the lesser sac of the peritoneum is formed by organs situated on the posterior wall of the cavity of the abdomen and which are covered by the parietal peritoneum, namely, on the right—the inferior vena cava and the abdominal aorta with the coeliac artery arising from it here; on the left—the left suprarenal gland, the upper end of the left kidney, the splenic vessels, and, distally—the body of the pancreas which accounts for the largest part of the posterior wall of the lesser sac.

The caudate lobe of the liver forms the upper wall of the lesser sac of the peritoneum; the transverse colon with its mesentery may be considered the lower wall. Consequently, the lesser sac is a peritoneal cavity which is closed on all sides except for one: an **opening into the lesser sac** *(foramen epiploicum)* in the right part of the sac behind the hepatoduodenal ligament is the exit from it, or rather, the entry into it. One or two fingers can be inserted into the opening. The hepatoduodenal ligament with the vessels and bile duct contained in it is the anterior wall of the opening; its poste-



482. *Course of peritoneum* (represented semischematically).
(Midsagittal section through the cavitites of the abdomen and pelvis of male subject.)



483. *Course of peritoneum* (represented semischematically).
(Midsagittal section through the cavities of the abdomen and pelvis of female subject.)

rior wall is the hepatorenal peritoneal ligament behind which are the inferior vena cava and the upper end of the right kidney. The upper border of the first part of the duodenum is the lower wall. The narrow part of the sac closest to the opening is the **vestibule of the omental bursa** *(vestibulum bursae omentalis)* which is bounded by the caudate lobe of the liver superiorly and by the head of the pancreas inferiorly.

Behind the caudate lobe of the liver, between it and the right crus of the diaphragm which is covered by the parietal peritoneum, is the **upper recess of the lesser sac** *(recessus superior omentalis)* which extends downwards in the direction of the vestibule. The **lower recess of the lesser sac** *(recessus inferior omentalis)* is situated downwards from the vestibule between the posterior wall of the stomach in front, and the pancreas covered by the parietal peritoneum and the transverse mesocolon behind. To the left of the vestibule the cavity of the lesser sac is narrowed by the peritoneal **gastropancreatic fold** *(plica gastropancreatica)* ascending to the left from the upper border of the tuber omentale of the pancreas to the lesser curvature of the stomach (the fold contains the left gastric artery *(arteria gastrica sinistra)*). The **lienal recess** *(recessus lienalis)* situated between the gastrosplenic ligament *(ligamentum gastrolienale)* and the **lienorenal ligament** *(ligamentum phrenicolienale)* is a continuation of the lower recess of the lesser sac to the left.

Two large mesenteric sinuses and two lateral canals are situated in the lower storey of the cavity of the abdomen on the posterior wall.

The mesenteric sinuses lie to both sides of the mesentery: on the right is the right mesenteric sinus, and on the left—the left mesenteric sinus. The right mesenteric sinus is bounded by the transverse mesocolon superiorly, by the ascending colon on the right, and by the mesentery on the left and inferiorly. The right mesenteric sinus is thus triangular and closed on all sides. Above, under the mesocolon (more to the right) the lower end of the right kidney is outlined and can be seen through the parietal peritoneum lining the sinus; the third part of the duodenum and the lower part of the head of the pancreas which it embraces are related to the right kidney here. Lower, in the right sinus the descending right ureter and the ileocolic artery and vein can be seen. The left mesenteric sinus is bounded by the transverse mesocolon superiorly, by the descending colon on the left, and by the mesentery on the right. Inferiorly it communicates with the peritoneal cavity of the true pelvis through the region of the promontory. The left mesenteric sinus is quadrangular in shape and open inferiorly. The following organs are outlined and can be seen through the parietal peritoneum lining the left mesenteric sinus: the lower half of the left kidney superiorly; the abdominal aorta lower and medially in front of the vertebral column; the bifurcations of the aorta and the inferior vena cava with the segments of the common iliac vessels draining into them are visible more to the right. The promontory can be seen below the bifurcation. The left testicular (ovarian) artery, the left ureter, and branches of the inferior mesenteric artery and vein are seen to the left of the vertebral column. In the upper part of the left mesenteric sinus around the initial part of the jejunum, between the duodenojejunal flexure and the superior duodenal fold (duodenojejunal fold) surrounding it is a narrow fissure in which the **superior duodenal recess** *(recessus duodenalis superior)* and the **inferior duodenal recess** *(recessus duodenalis inferior)* are distinguished.

Under the ileocaecal fold above and below the ileum are pouches which are called the **superior ileocaecal recess** *(recessus ileocaecalis superior)* and **inferior ileocaecal recess** *(recessus ileocaecalis inferior)*. A **retrocaecal recess** *(recessus retrocaecalis)* (Fig. 477) is sometimes found under the fundus of the caecum.

The right lateral canal is to the right of the ascending colon; it is bounded by the parietal peritoneum of the lateral abdominal wall laterally and by the ascending colon medially; inferiorly it communicates with the iliac fossa and the peritoneal cavity of the true pelvis. The right canal communicates superiorly with the subhepatic and suprahepatic recesses of the hepatic bursa. To the left of the descending colon is the left lateral canal. It is bounded laterally by the parietal peritoneum lining the lateral abdominal wall. Inferiorly the canal opens into the iliac fossa and then into the cavity of the true pelvis. The phrenicocolic ligament, which is described above, crosses the canal above on the level of the left flexure of the colon. Superiorly and to the left the canal communicates with the pregastric bursa.

A peritoneal **recess of the pelvic mesocolon** *(recessus intersigmoideus)* (Fig. 477) is formed at the apex of the angulated attachment of the pelvic mesocolon.

Along the extension of the ascending and descending colon both canals are sometimes separated laterally by more or less developed peritoneal folds and adjacent **paracolic grooves** *(sulci paracolici)* (Fig. 477).

The topography of the peritoneum in the cavity of the true pelvis is described in the section *The Urogenital Apparatus* of this volume.

DEVELOPMENT AND AGE FEATURES OF THE DIGESTIVE APPARATUS[1]

The digestive system of the newborn differs essentially from that of the adult (Figs 483 A, 483 B).

The cavity of the mouth develops from the oral pit (stomadeum) which is lined with ectoderm; the pit becomes deeper gradually and reaches the cephalic end of the foregut; both germ layers, the ectoderm and entoderm, fuse here. The oral pit is bounded above by the frontal eminence which forms due to active growth of the brain; on the sides and below, the oral pit is bounded by the visceral arches. The face and the cavity of the mouth develop later from these buds.

The cavity of the mouth is very poorly developed in the newborn. Later with the development of the jaws, eruption of the teeth and enlargement of the palate it grows gradually and the vestibule and the cavity proper of the mouth form. The mucous membrane of the vestibule of the mouth forms a series of folds: the frenula of the lips, the buccal bands, and transverse folds on the hard palate. Bands of epithelial tissue lie in the posterior part of the hard palate to both sides of the midline in the newborn and in a child up to 2 or 3 years of age. The hard palate itself in the newborn and in infants in the first months of life is flattened and its vaulted shape is very weakly pronounced in comparison with that in adults. Before the development of the vestibule, the cavity of the mouth is entirely occupied by the tongue which in the newborn and in infants of the first months of life is extremely broad and very flat. The tongue is laid down as several lingual swellings which are buds lying on the floor of the primary cavity of the mouth: one unpaired swelling *(tuberculum impar)* lying on the midline, and two lateral swellings. The swellings which are situated in front of the foramen caecum at the tongue give rise to the body (dorsum and tip) of the tongue, while the swelling which lies to the back of the foramen caecum gives rise to the root of the tongue. All these lingual germs fuse quickly and leave a mark at the junction of the root with the body of the tongue in the form of the **sulcus terminalis** in front of and along which are the vallate papillae. The epithelial layer of the tongue forms papillae among which the vallate papillae and folia linguae appear first and the fungiform and the filiform papillae later. The muscles of the tongue develop from the myotomes of the occipital region which grow into the root of the tongue.

The cavity of the mouth is divided into the cavity proper of the mouth and the vestibule of the mouth, the gums, the alveolar process of the maxilla and the alveolar part of the body of the mandible, and the teeth which are laid down in them (first the deciduous and later the permanent teeth) (see *The Teeth*).

The teeth are laid down in the second month of intrauterine life; the enamel is derived from the ectoblast while the dentine, cement, and pulp form from the mesoblast. The **dental lamina** *(lamina enamelare)*, which is the first to appear, grows into the underlying mesenchyme which gives rise to the gingival swellings. Bulges then form on the dental lamina due to growth of epithelium, and the **enamel organs** of the deciduous teeth form in this manner. Mesenchyme penetrates them on the 10th week, from which the **dental papillae** *(papillae dentales)* are derived. Later they separate partly from the dental lamina and remain joined to it by an epithelial cord. Besides, the mesenchyme surrounding the enamel organ thickens in this period to form the **dental sac** *(saccus dentalis)* which fuses with the dental papilla. All these changes occur in the first developmental stage. The second stage of development is marked by further changes in the tooth germs—they separate from the dental lamina into which the mesenchyme grows and which loses connection with the epithelium of the cavity of the mouth. In the third stage, in the fourth month of embryonal development, the dentine, enamel, and the pulp of the tooth form.

The crown forms before the infant is born, while the roots of the deciduous teeth develop after their eruption. The commonly encountered order of eruption of the deciduous teeth is as follows: medial incisors—between the 6th and 8th month of life; lateral incisors—from the 7th to the 9th month; first molars—between the 12th and 15th month; canine teeth—from the 15th to 20th month; second molars—from the age of 20 to 30 months. The lower teeth erupt a little earlier than the corresponding upper ones.

As to the salivary glands, they hardly differ from those of an adult, but in the newborn the large salivary glands (parotid, sublingual, submandibular) have a pronounced lobulated structure.

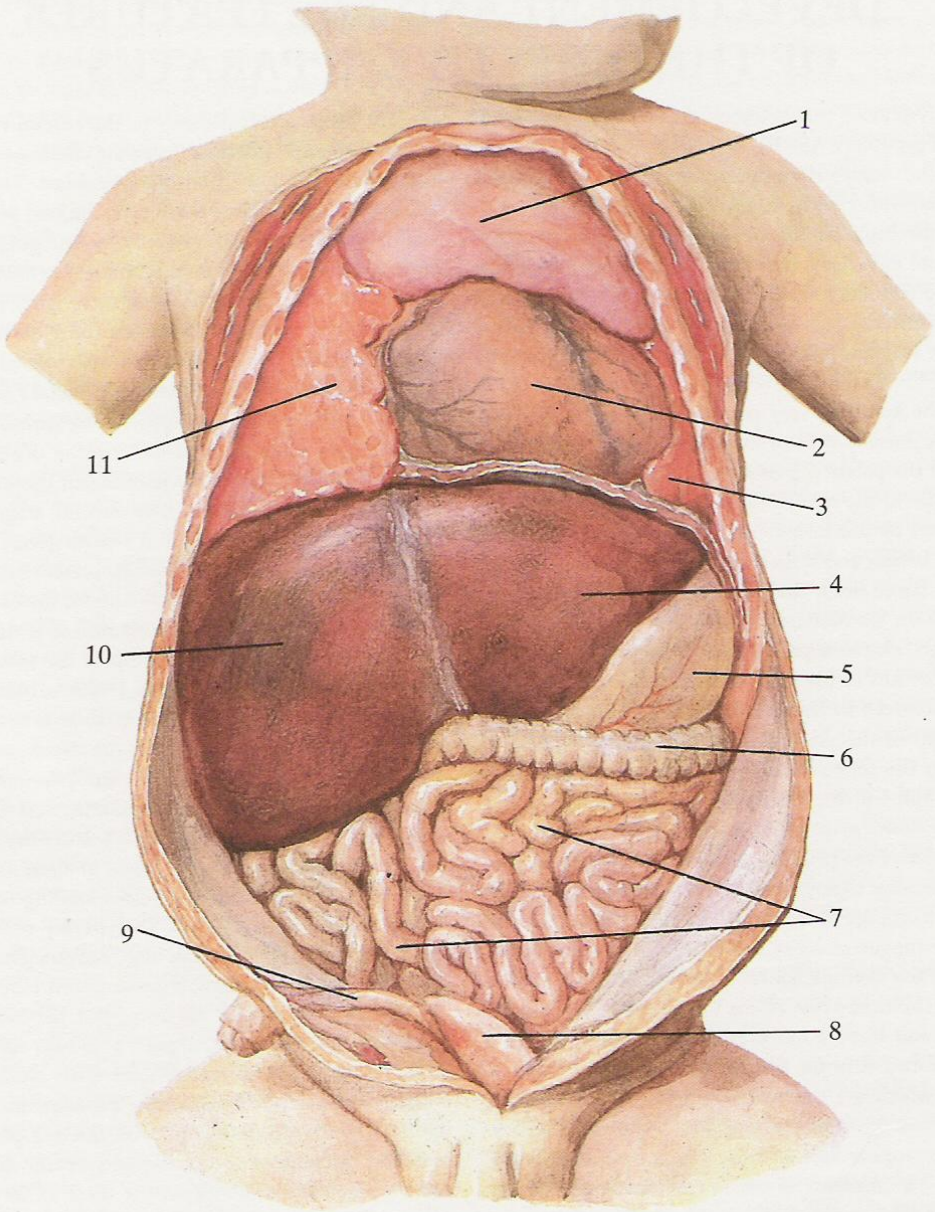
The pharynx of the newborn, just like that of the adult, has three parts: an upper, nasal, part; a middle, oral, part; and a lower, laryngeal, part. The nasopharynx in early childhood does not have a high vault but is rather flat; the choanae through which the cavity of the nose communicates with the nasopharynx are very narrow. The opening of the pharyngotympanic tube in the newborn and very young infants is on the level of the hard palate, while in an adult it is on the level of the posterior end of the inferior nasal concha. This is explained by the development of the upper jaw and the consequent descent of the floor of the cavity of the nose.

The junction of the pharynx with the oesophagus is on the level of the fourth-fifth cervical vertebrae in the newborn and on the level of the sixth cervical vertebra in the adult.

The nasopharyngeal tonsil is poorly developed, varies in shape, and often grows in size rapidly.

The oesophagus is laid down at the same time as the respiratory organs from the foregut. The oesophagus of the newborn begins at the level of the fourth-fifth cervical vertebrae and in contrast to that of an adult is funnel-shaped. Its length varies from 10

[1] In view of the fact that students will study the age features after they are acquainted in detail with the anatomy of a human adult, in this section as well as in other similar sections we dwell only on some age peculiarities. For details of development we refer the reader to a textbook of embryology.



483A. *Organs of cavities of thorax and abdomen of the newborn.*

1—thymus
2—heart
3—left lung
4—liver, left lobe
5—stomach
6—colon
7—small intestine
8—urinary bladder
9—median umbilical fold
10—liver, right lobe
11—right lung

to 16 cm, whereas the oesophagus of an adult measures 26 cm in length.

The cervical part of the oesophagus is situated slightly higher in the newborn than in an adult, but descends with age, particularly intensively to the age of 10–12 years. The rich amount of adventitial tissue in the wall of the oesophagus in the newborn and infants makes it very mobile, though the muscular layers are still poorly developed. The junction of the oesophagus with the stomach in the newborn is projected at the level of the tenth-eleventh thoracic vertebrae.

The stomach forms from the posterior part of the foregut. In the fourth week of embryonal development it has the appearance of a spindle-shaped distention and gradually grows in width. The age-specific shape and position of the stomach are characterized by a less pronounced convexity of the fundus and the greater curvature of the stomach of a newborn (a shape resembling a cylinder) and an almost vertical position. The capacity of the stomach varies from 30–35 cm^3 to 150 cm^3 in the newborn, but increases rapidly in the first year of life and reaches 300 cm^3 by the age of 12 months. The stomach changes its position after birth: it descends gradually. The cardia in the newborn is on the level of the eighth-ninth thoracic vertebrae, the pylorus—on the level of the ninth to twelfth vertebrae. In infants the stomach is almost pear-shaped and lies rather horizontally and at a higher level, being displaced by the distended intestinal loops; but at the same time this position is evidently determined to a greater extent by the degree of its embryonic rotation. However, the shape and position of the stomach may also change under the effect of its filling as well as the filling of the organs adjacent to it. The stomach of infants is almost completely covered by the liver.

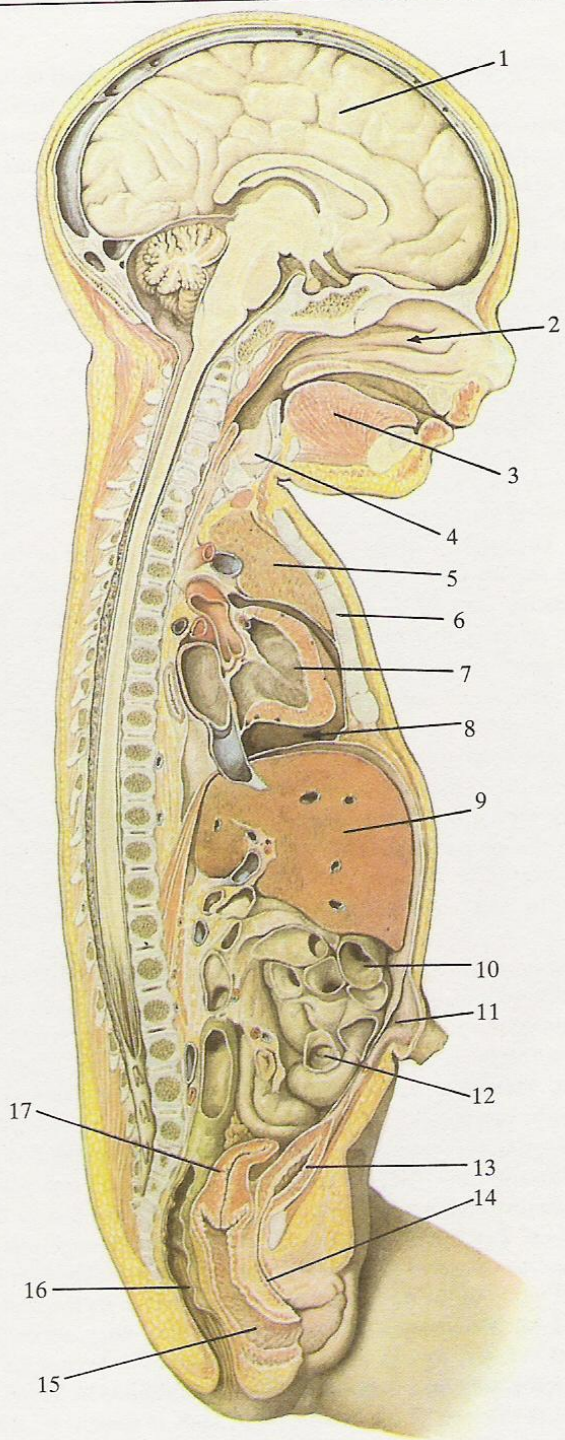
The intestine from the pyloric portion of the stomach to the cloaca develops at the end of the first month of intrauterine life from the primary gut. Later, the straight primary gut forms a loop whose anterior limb differentiates into the duodenum, jejunum, and the greater portion of the ileum, while the posterior limb forms the terminal portion of the ileum, the caecum with the vermiform appendix, and the entire colon down to the anus.

The duodenum of the newborn differs in some features from that of an adult. It is usually ring-shaped and has no visible boundaries between its parts. By the age of 2 or 3 years this shape is encountered much less frequently and the shape of the duodenum resembles that of adults more and more. In the newborn the first part of the duodenum and its end (the duodenojejunal flexure) are almost on the same level and the first part is situated higher than in an adult; beginning from the age of 5–6 months of life this part of the duodenum descends to the level of the twelfth thoracic vertebra and continues to descend still lower with age to the level of the body of the first lumbar vertebra.

The intensive growth of the primary gut leads to the formation of numerous intestinal loops whose position in the cavity of the abdomen may be vertical or horizontal depending mainly on the position of the root of the mesentery, whether it is horizontal or vertical. The root of the mesentery of a newborn is situated rather high: its beginning is on the level of the first lumbar vertebra while the end is at the level of the fourth lumbar vertebra. The intestine descends gradually later. It grows most rapidly between the age of 12 months and 3 years and between 10 and 15 years. The relative length of the intestine reduces with age. For instance, it is quite long in the newborn and is six- to sevenfold the length of the body, but in an adult it is 3 to 4.5 times the length of the body.

In the early period after birth the caecum with the vermiform appendix is a small funnel-shaped protrusion which is situated almost under the liver. This high position changes to a lower one, to the level of the iliac crest, in the beginning of the second month. Later the caecum descends still more into the cavity of the pelvis, which usually occurs at the age of 12–14 years. The position of the vermiform appendix is extremely variable. The opening of the appendix in the newborn is devoid of a fold and gapes widely; the fold begins to form at the end of the first year of life. The ascending colon is longer than the descending colon in the intrauterine period but shorter in the newborn and becomes as long as the descending colon only by the age of 4 years; by the age of 7 years it is the same length as the ascending colon in an adult. The ascending colon is situated under the liver in the newborn, descends gradually with age, and is in the region of the iliac fossa in the 13–15-year-olds. A slightly increased number of flexures distinguishes the ascending colon in particular. The transverse colon is in the epigastric region in the newborn because its mesentery is short at this age; by the age of 18 months the mesentery grows in length almost threefold and the transverse colon sinks, and even sags in adults. The pelvic colon in children has a long mesentery as a result of which it reaches the level of the transverse mesocolon superiorly or stretches to the right to the ascending colon. A great number of folds and intestinal glands occur on the whole colon but the taeniae and sacculations are less developed. At old age the taeniae are thin, while the sacculations and folds are smaller and less in number. The folds of the mucous membrane in the rectum of the newborn are hardly pronounced. The other structures of the rectum (columns, sinuses, etc) are just as poorly developed. The position of the rectum in children is almost vertical because the sacrum stands straight in relation to the vertebral column.

The liver and pancreas are laid down almost at the same time at the end of the first or beginning of the second month of intrauterine life due to growth of the entodermal epithelium of the future duodenum. The liver in the newborn almost fills the epigastric region and covers the stomach completely; the left lobe of the liver is especially large, while the lower border lies at the level of the umbilicus. The liver of the newborn accounts for 4–5 % of the total body weight and its weight is slightly more in boys than in girls (in an adult it constitutes 3 % of the total body weight). It weighs 150 g on the average at birth, double that by the end of the first and beginning of the second year of life, and increases threefold in weight by the age of 3 years. The liver grows particularly intensively at 14–15 years of age in the pubertal period, and its weight increases to 1300 g. Areas devoid of hepatic lobules but containing naked 'stray' bile ducts appear in the liver with age due to growth of intrahepatic connective tissue and the pressure exerted on the liver by the adjacent organs (stomach, gall blad-



483B. *Midsagittal section through head and cavities of the thorax, abdomen, and pelvis of the newborn.*

1—brain
2—cavity of nose
3—tongue
4—larynx
5—thymus
6—sternum
7—heart, cavity of left ventricle
8—cavity of pericardium
9—liver
10—colon
11—umbilicus
12—large intestine
13—urinary bladder
14—urethra
15—vagina
16—rectum
17—uterus

der, etc) and vessels (inferior vena cava, branches of the proper hepatic artery and portal vein). One of such areas which is next to the left triangular ligament is called the **fibrous appendix of the liver** *(appendix fibrosa hepatis)*. 'Stray' bile ducts are also found in the grooves and peritoneal ligaments of the liver, and in the lower border of the left lobe (Figs 483 A, 483 B). The lower border of the liver of the newborn stands out from under the costal arch on the midline 3.5–4 cm from the xyphoid process; the upper boundary is on the right axillary line between the fifth and sixth ribs. The gall bladder of the newborn is usually spindle-shaped and almost always protrudes from under the border of the liver; its fundus is projected 2 cm to the right of the midline and 4 cm below the costal arch. The pancreas of the newborn is shaped almost like a trihedral prism and acquires the shape characteristic of the gland of an adult only by the age of 5–6 years. It weighs 2.5–3.0 g on the average and measures 3–6 cm in length, 0.9–1.6 cm in breadth, and 0.38–1.0 cm in thickness. By the age of 4 months its weight increases twofold; by the age of 9 years, threefold. The pancreas is loosely attached to the posterior abdominal wall and is relatively mobile.

THE RESPIRATORY SYSTEM (THE RESPIRATORY APPARATUS)

Systema respiratorium (Apparatus respiratorius)

The **respiratory system** *(systema respiratorium)*, or the **respiratory apparatus** *(apparatus respiratorius)* is responsible for the gaseous exchange in the body, which is necessary for sustaining life.

Gases are exchanged between the air inspired from the external environment and the blood. The exchange occurs in the lungs which are specialized in diffusion of gases through the thin wall of their **alveoli** *(alveoli pulmonis)*. The diffusion of gases takes place in two directions: from the alveoli into the capillaries and from the capillaries into the alveoli. During this process the blood receives oxygen of the environmental air via the lungs and gives up carbon dioxide which is produced as the result of tissue metabolism. Thus, the respiratory apparatus acts as a system of provision and as a system of elimination, which is an indispensable condition for maintaining the constancy of the body's internal environment.

The respiratory system consists of the following structures (Fig. 484): the **cavity of the nose** *(cavum nasi)*, the **pharynx** (see *The Digestive System*), the **larynx**, the **trachea**, the **bronchi** and their branchings, and the **lungs** *(pulmones)*.

Still another important function of the respiratory apparatus is the production of the voice, for which the larynx is the main organ.

Sound is produced in the larynx by vibration of the vocal ligaments and is modulated by the resonating chambers (upper respiratory tract, paranasal sinuses, and the cavity of the mouth).

THE CAVITY OF THE NOSE

The **nose** (*nasus* s. *rhinos*) is the first part of the respiratory system and the peripheral part of the olfactory apparatus (see Vol. III, *The Organ of Smell*).

The **cavity of the nose** *(cavum nasi)* (Figs 485–493) is separated by the **septum of the nose** *(septum nasi)* into two almost symmetrical parts.

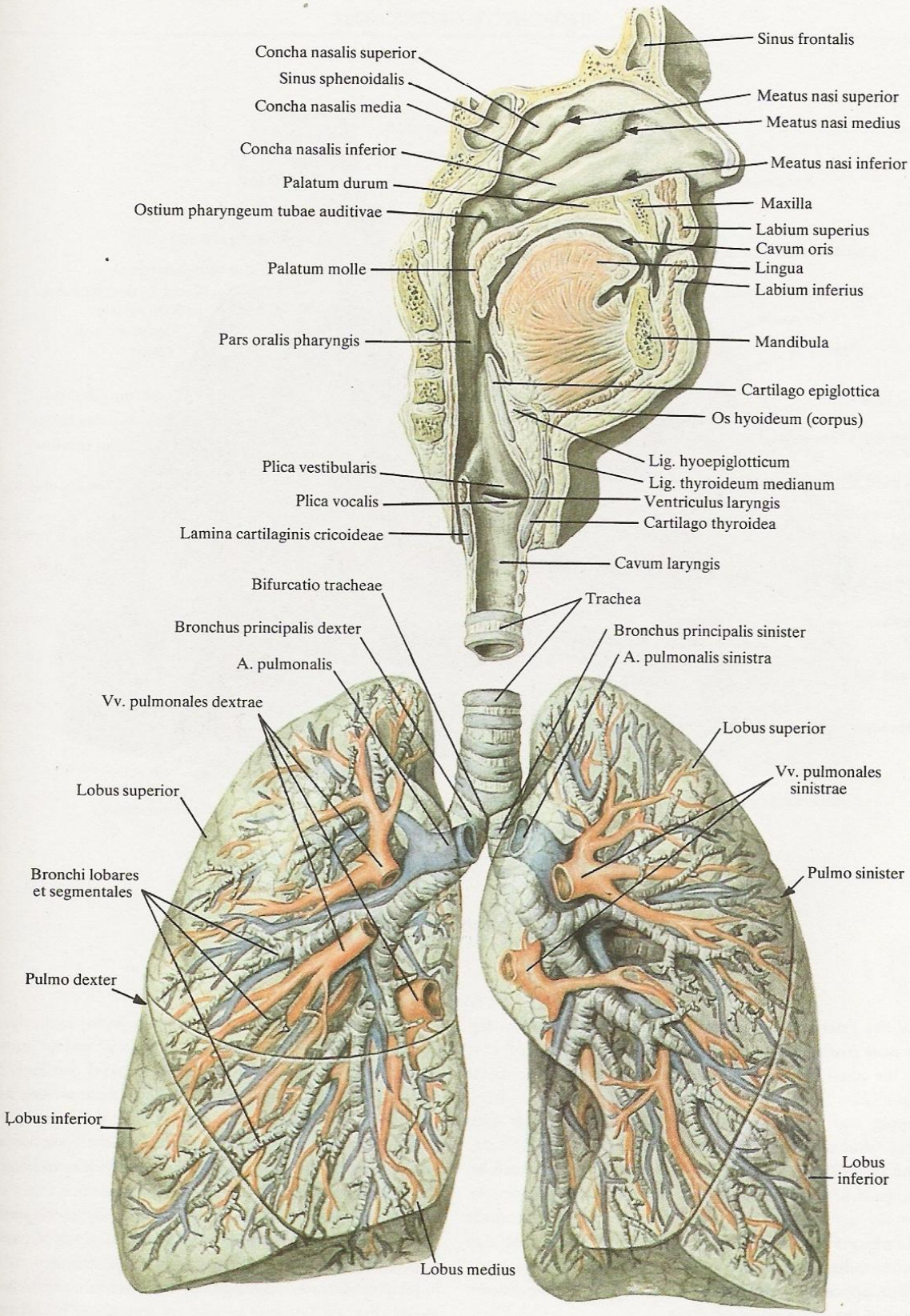
The septum of the nose has a **membranous part** *(pars membranacea)* and a **bony part** *(pars ossea)* (the latter is described in Vol. I, *The Skull as a Whole*).

The membranous part is mostly formed by the **cartilages of the nose** *(cartilagines nasi)*. The **septal cartilage** *(cartilago septi nasi)* (Fig. 489), a plate of an irregular quadrangular shape, makes up the greater part of the membranous septum. The posterosuperior border of the septal cartilage is wedged in an angle formed by the perpendicular plate of the ethmoid bone and the vomer. The upper parts of this border join the anterior border of the perpendicular plate, while the lower parts join the anterior border of the vomer and the anterior parts of the nasal crest *(crista nasalis)* and the anterior nasal spine *(spina nasalis anterior)*.

The narrowest part of the cartilage is called the **sphenoidal process of the nasal septum** *(processus posterior sphenoidalis)*.

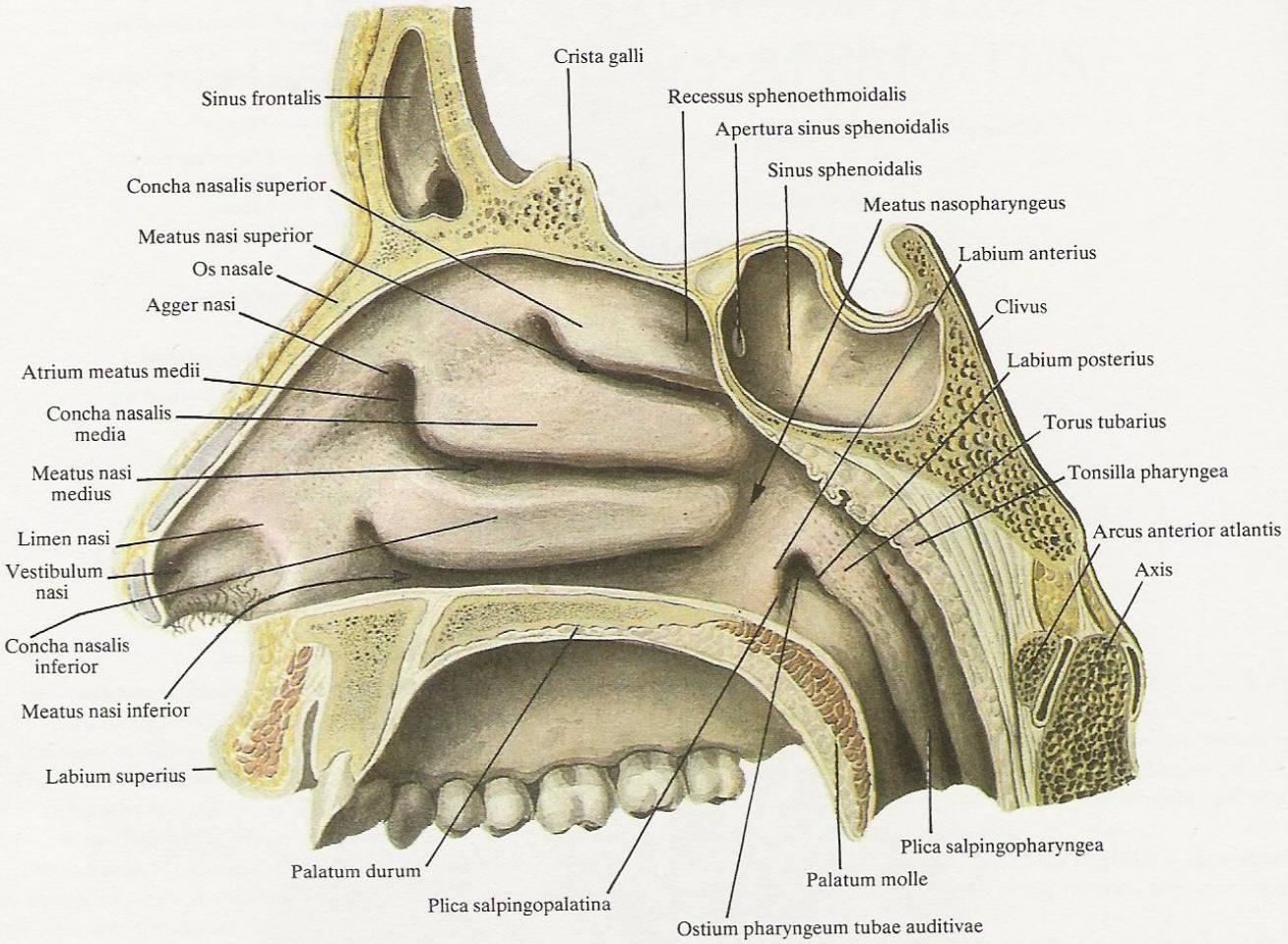
The anteroinferior border stretches to the septal process *(crus mediale)* of the lower nasal cartilage. The anterosuperior border of the septal cartilage runs to the inner surface of the bridge of the nose in the region of the suture between the nasal bones.

The **dorsum (bridge) of the nose** *(dorsum nasi)* is a narrow con-



484. *Respiratory apparatus* (represented semischematically).

(Sagittal section through the cavities of the nose, mouth and larynx, slightly deviated from the midplane.)



485. *Cavity of nose (cavum nasi);* right side ($^1/_1$).

vex part of the **external nose** *(nasus externus)* extending from the **root of the nose** *(radix nasi)* to the **apex of the nose** *(apex nasi)*. It is formed by the nasal bones, upper nasal cartilages, and the septal cartilage.

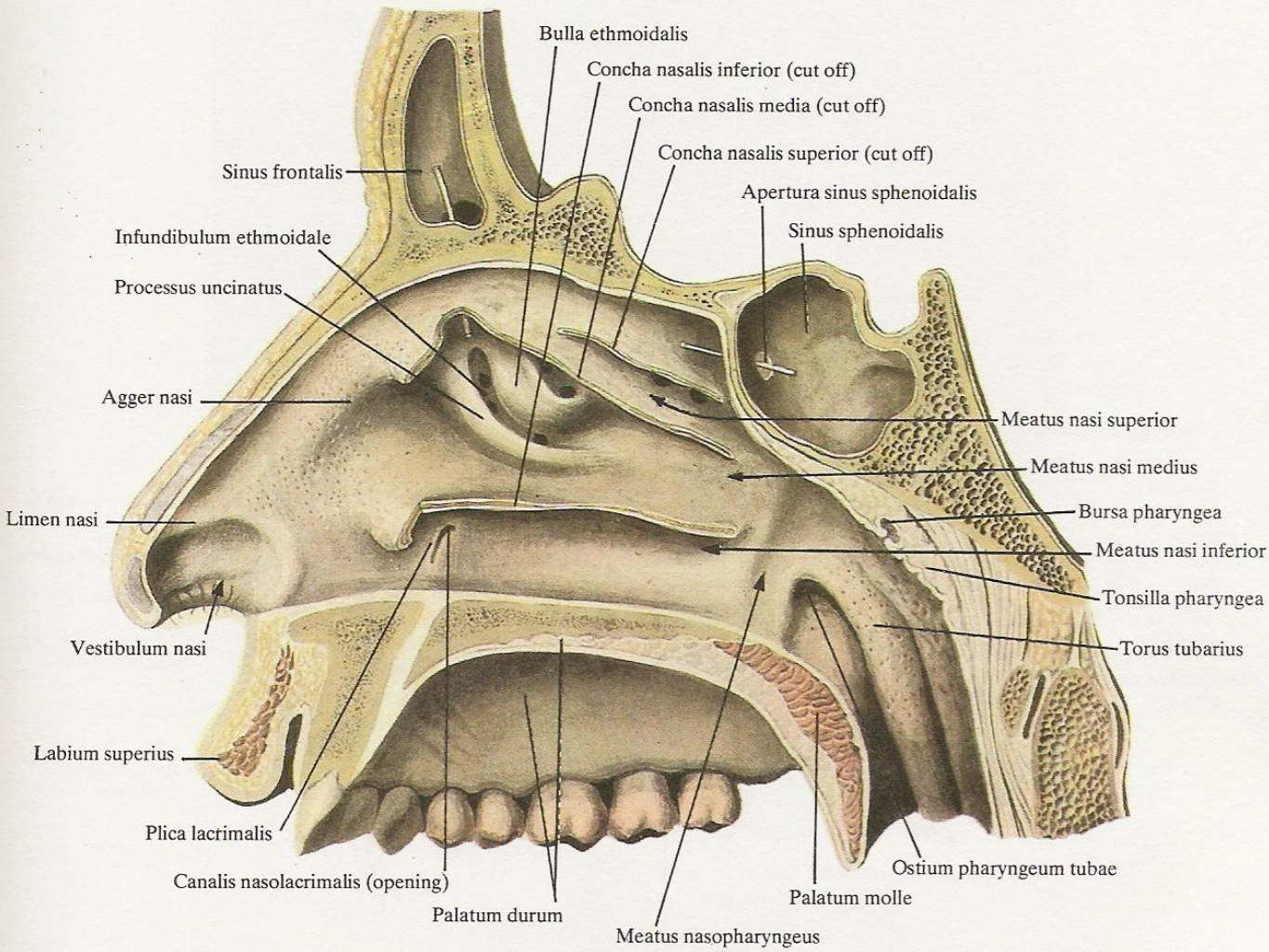
The **upper nasal cartilage** *(cartilago nasi lateralis)* (Figs 490, 491) is paired and shaped like an irregular triangle. It contributes to the formation of the lateral wall of the nose. The posterior border of the upper nasal cartilage adjoins the anterior border of the nasal bone; the upper part of the medial border comes in contact with the border of the contralateral cartilage with which it may fuse, while the inferior part adjoins the septal cartilage; the lower border of the upper nasal cartilage extends to the septal process *(crus mediale)* of the lower nasal cartilage.

The **lower nasal cartilage** *(cartilago alaris major)* (Figs 491, 492) is paired and together with the contralateral cartilage binds the external openings of the nose, the **nostrils** *(nares)* laterally, anteriorly, and medially. A **septal process** *(crus mediale)* and an **outer part** *(crus laterale)* are distinguished in the lower nasal cartilage. The septal processes of both lower nasal cartilages separate one nostril from the other, and the anteroinferior border of the septal cartilage is wedged between them. The outer part of the lower nasal cartilage is wider and longer than the septal process; it is convex and forms the cartilaginous skeleton of the ala of the nose.

Two or three **small cartilages of the ala** *(cartilagines alares minores)* situated in the posterosuperior parts of the ala are joined to the outer part of the lower nasal cartilage.

A few **sesamoid cartilages of the nose** *(cartilagines nasales accessoriae)* (Fig. 490) of various size are sometimes found between the outer part and the upper nasal cartilage.

The cartilages of the nose are covered by perichondrium and



486. *Cavity of nose (cavum nasi);* right side ($^1/_1$).

(Most of the conchae are removed.)

are joined to one another and to the adjacent bones by fibrous tissue.

The cavity of the nose *(cavum nasi)* consists of the vestibule of the nose *(vestibulum nasi)* which is lined with skin continuing into it from the outer surface of the nose through the nostrils, and the cavity of the nose proper which is lined with mucous membrane.

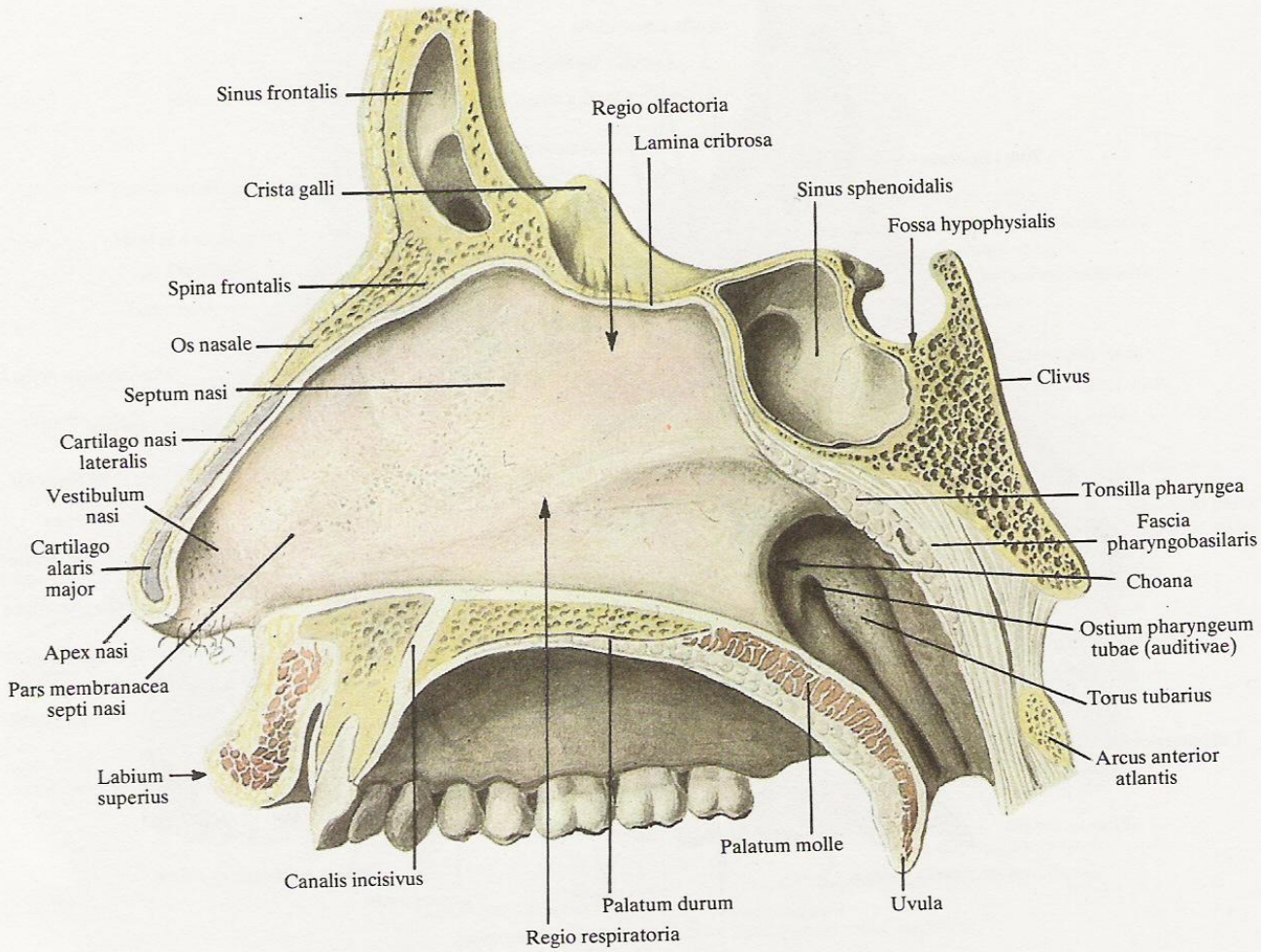
The **vestibule of the nose** *(vestibulum nasi)* is separated from the cavity of the nose proper by a small ridge called the **limen nasi** (Fig. 486) which is formed by the upper border of the outer part of the lower nasal cartilage.

In the anterior parts of the cavity of the nose proper is a small ridge-like elevation called the **agger nasi** (Figs 485, 486) which runs from the anterior end of the middle nasal concha to the limen nasi.

To the front of the agger nasi, between it and the inner surface of the bridge of the nose, is an elongated keel-shaped area. The **atrium of the middle meatus** *(atrium meatus medii)* is situated to the back of the agger nasi.

The greater part of the cavity of the nose proper is made up of the meatuses of the nose (Figs 485, 493) whose bony walls, as well as the walls of the cavity itself, are described in Vol. I *(The Skull as a Whole)*.

The mucous membrane is fused closely with the bony walls of the cavity of the nose and extends into the paranasal sinuses



487. *Septum of nose (septum nasi);* from left side ($^1/_1$).

(Mucous membrane.)

through the respective openings. As a result it makes these openings narrower and the meatuses rather smaller than their bony skeleton.

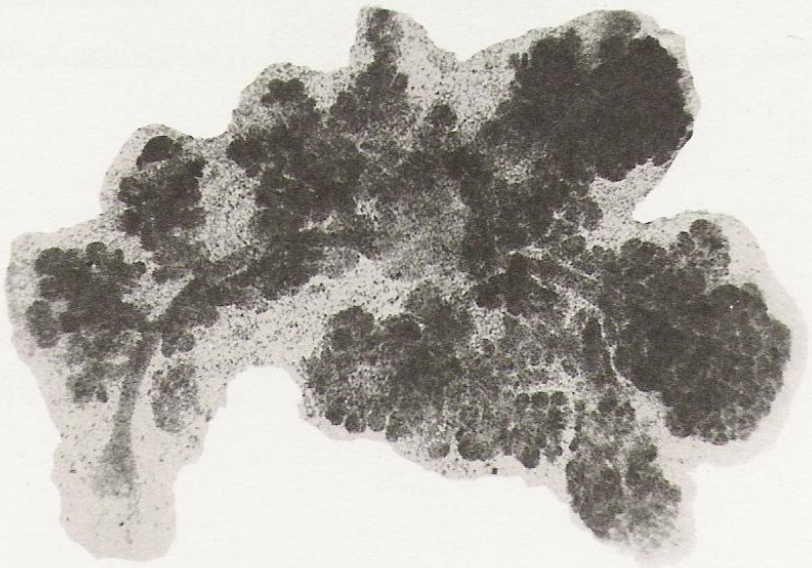
The mucous membrane in the anterior parts of the cavity of the nose proper is a continuation of the skin lining the vestibule of the nose; the mucous membrane of the posterior parts is continuous through the **posterior apertures of the nose** *(choanae)* with the mucous membrane of the pharynx and soft palate.

The mucous membrane of the cavity of the nose and that of the paranasal sinuses contains mucous **nasal glands** *(glandulae nasales)* which vary in size, shape, and number in the different areas (Figs 488 A, 488 B).

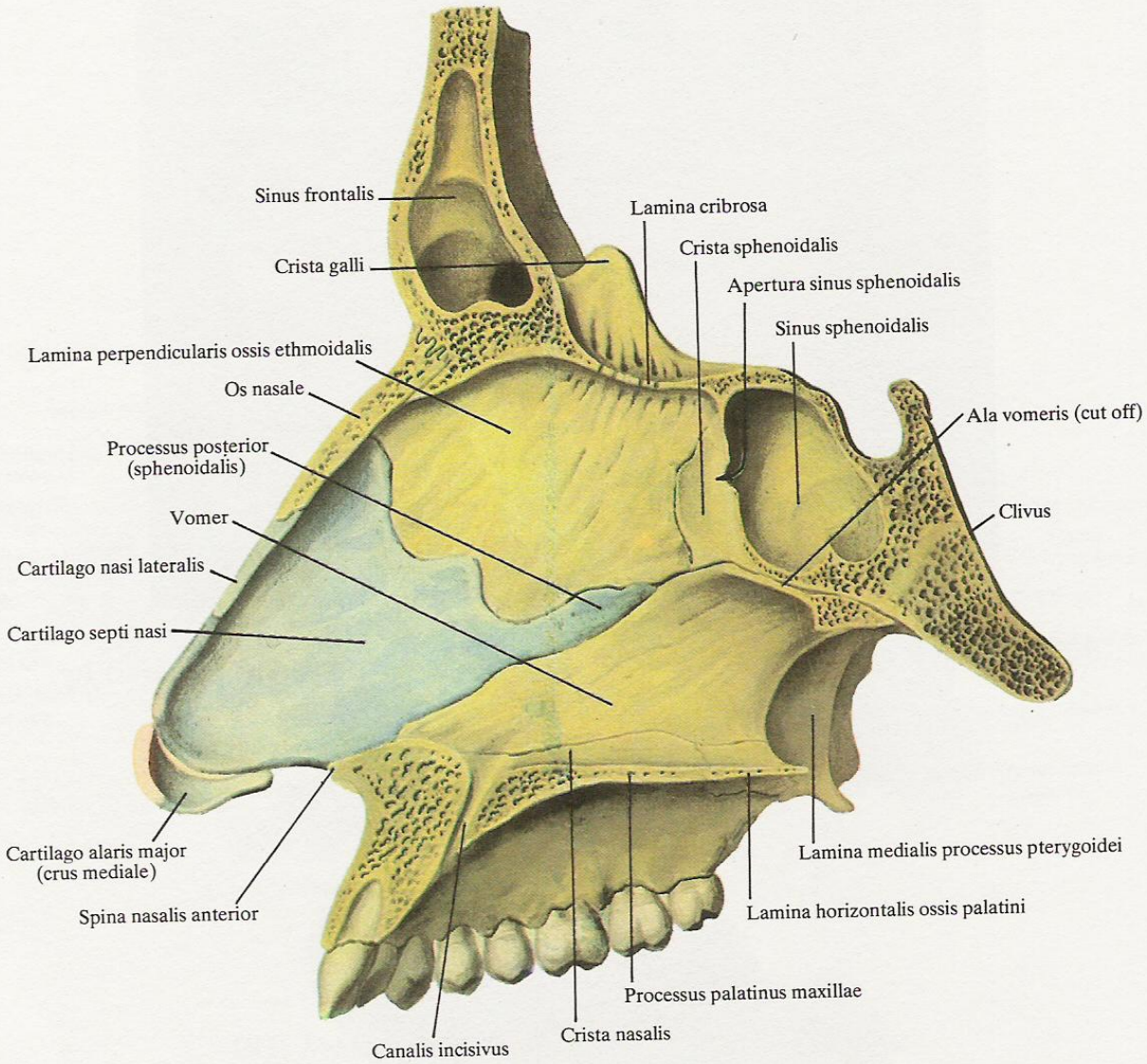
Many blood and lymph vessels pass in the submucous coat; a dense network of small vessels form **venous cavernous plexuses of the conchae** *(plexus venosus cavernosi concharum)* in the middle and inferior nasal conchae. The mucous membrane of the anteroinferior part of the cartilaginous septum of the nose bears sometimes a small opening behind and above the opening into the incisive canal, which leads into a blind canal called the **vomeronasal organ** *(organum vomeronasale)*. It is bounded laterally by the **subvomerine cartilage** *(cartilago vomeronasalis)*.

The respiratory and olfactory regions (*regio respiratoria* et *regio olfactoria*) are distinguished in the mucous membrane of the cavity of the nose.

488A. *Glands of mucous membrane of cavity of nose* (specimen prepared by S. Shapiro).
(Photomicrograph.)
(Group of glands from completely stained mucous membrane of inferior meatus of nose.)

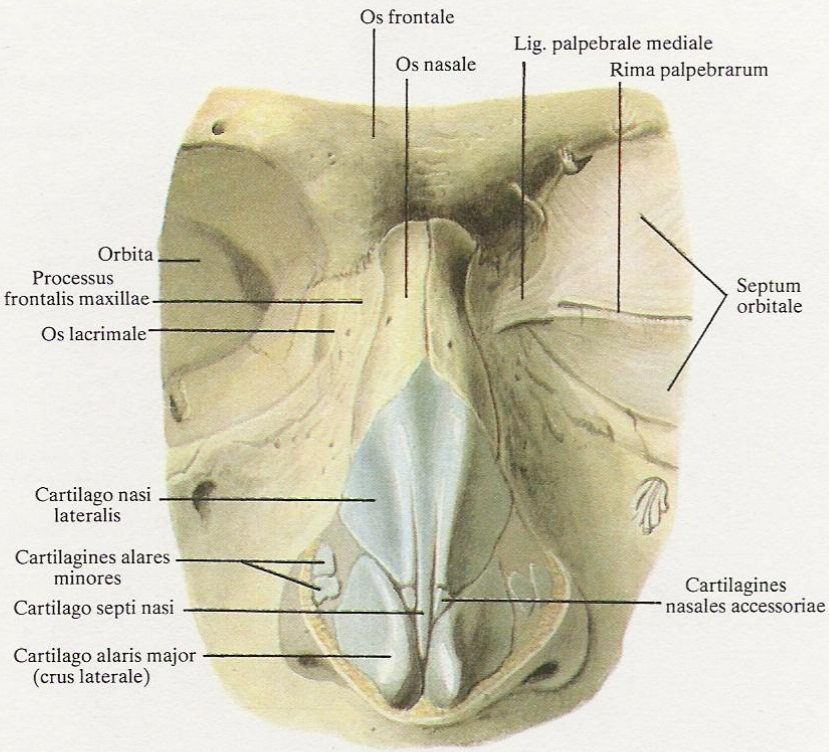


488B. *Gland of mucous membrane of maxillary sinus* (specimen prepared by S. Shapiro).
(Photomicrograph.)
(Gland isolated from completely stained mucous membrane.)



489. *Septum of nose (septum nasi);* from left side ($^1/_1$).

(The mucous membrane of the septum is removed; the osseous and cartilaginous skeletons of the septum can be seen. The cartilages of the nose are coloured blue.)

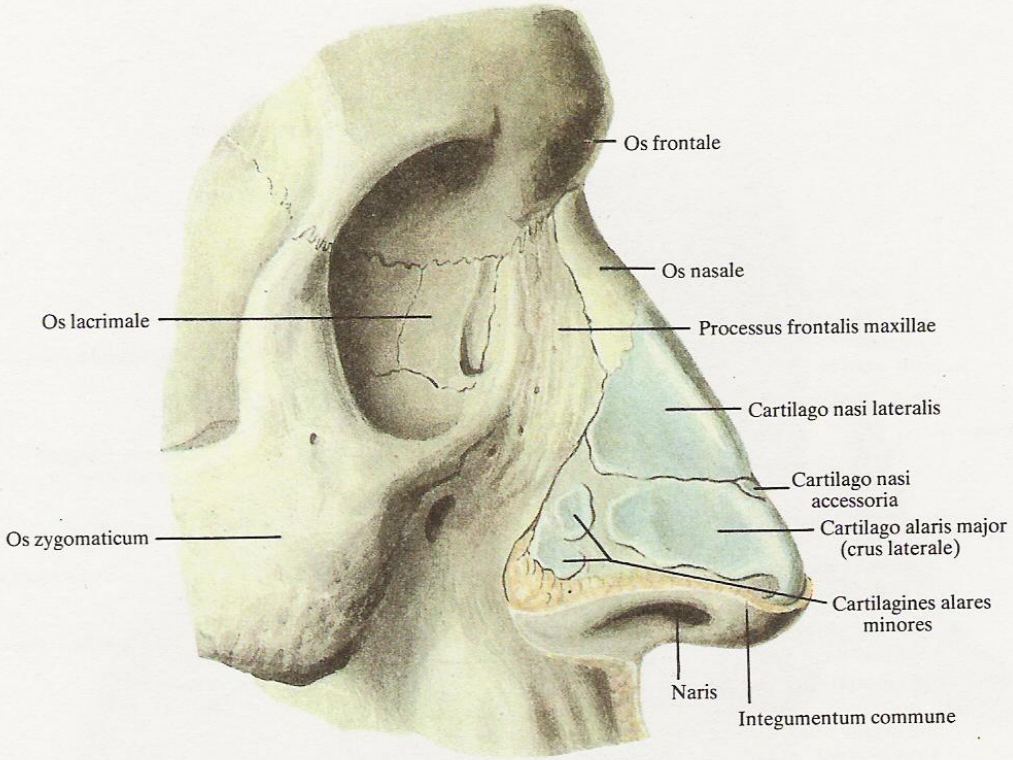


490. *Cartilages of nose (cartilagines nasi);* anterior aspect ($^1/_1$).

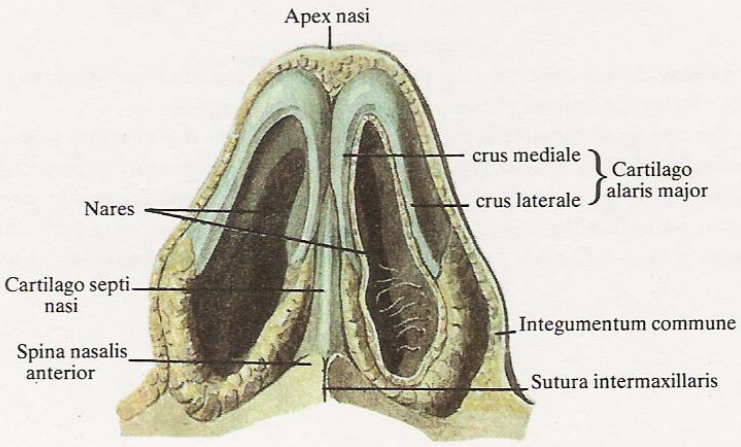
Part of the mucous membrane lining the superior conchae, the free surfaces of the middle conchae facing the septum of the nose, and the respective upper part of the septum of the nose is related to the **olfactory region** *(regio olfactoria)*. Olfactory glands *(glandulae olfactoriae)* and the ends of the olfactory nerves *(nervi olfactorii)* are embedded in the mucous membrane here. (For the description of these regions see Vol. III, *The Organ of Smell*.) The rest of the mucous membrane of the cavity of the nose belongs to the **respiratory region** *(regio respiratoria)*.

Innervation: the olfactory region—the olfactory nerves *(nervi olfactorii)*; the respiratory region—the ophthalmic and the maxillary nerves (*nervi ophthalmicus* et *maxillaris*).

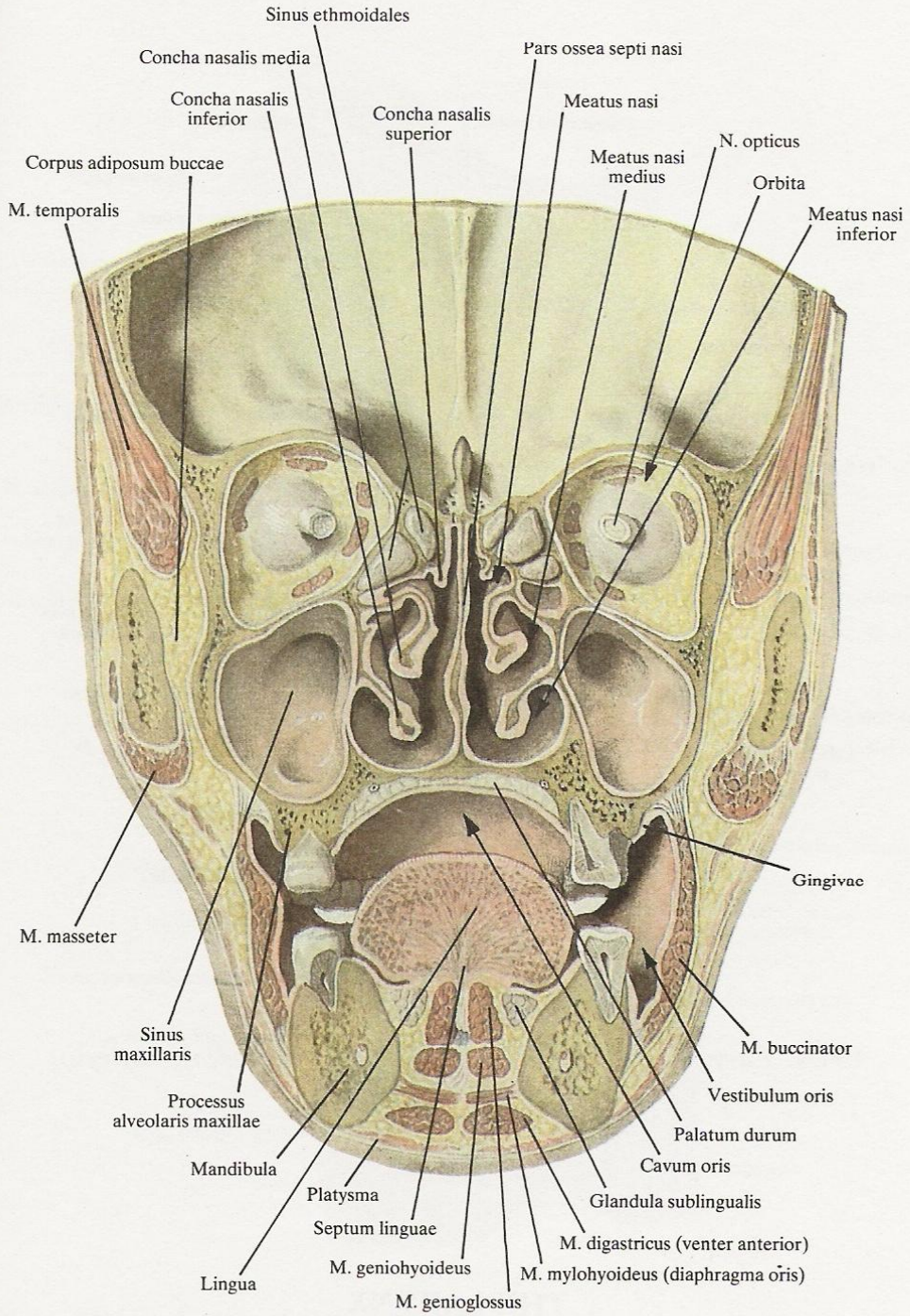
Blood supply: branches from the maxillary, ophthalmic, and facial arteries *(arteriae maxillaris, ophthalmica, facialis)*.



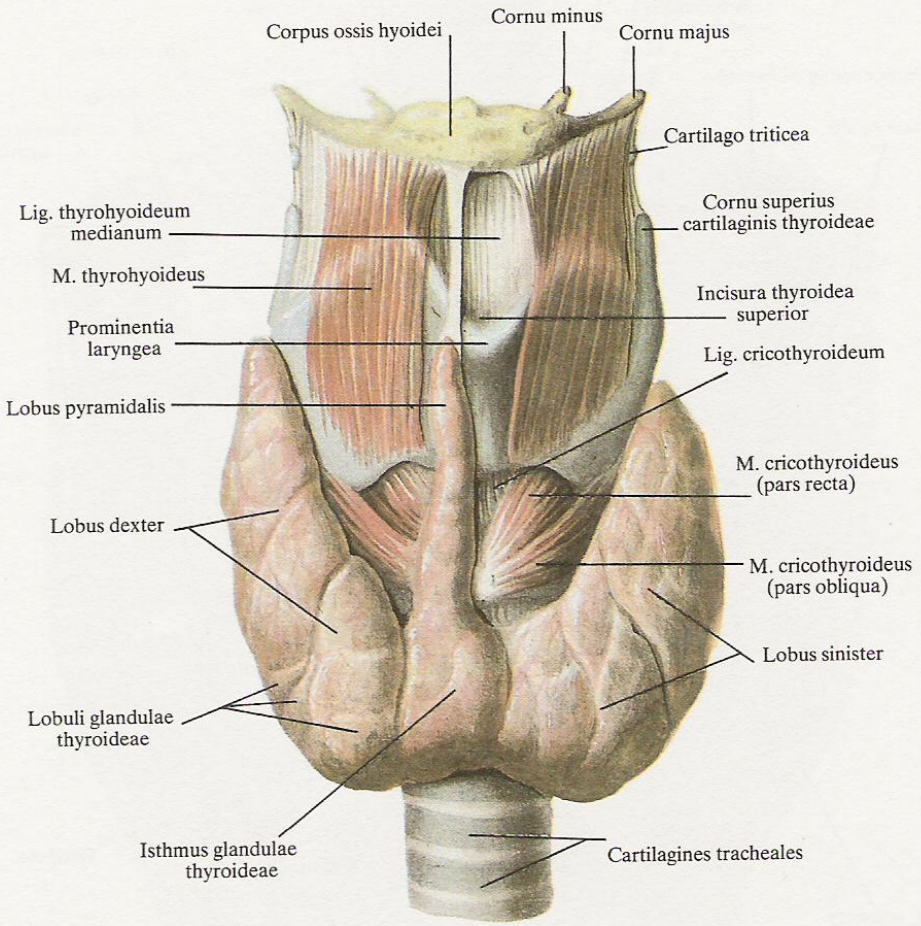
491. *Cartilages of nose (cartilagines nasi);* right side ($^1/_1$).



492. *Cartilages of nose (cartilagines nasi);* inferior aspect ($^3/_2$).



493. Frontal section of head ($^4/_5$).
(Section through second molars; posterior aspect.)



494A. *Larynx and thyroid gland (glandula thyroidea);* anterior aspect ($^5/_4$).

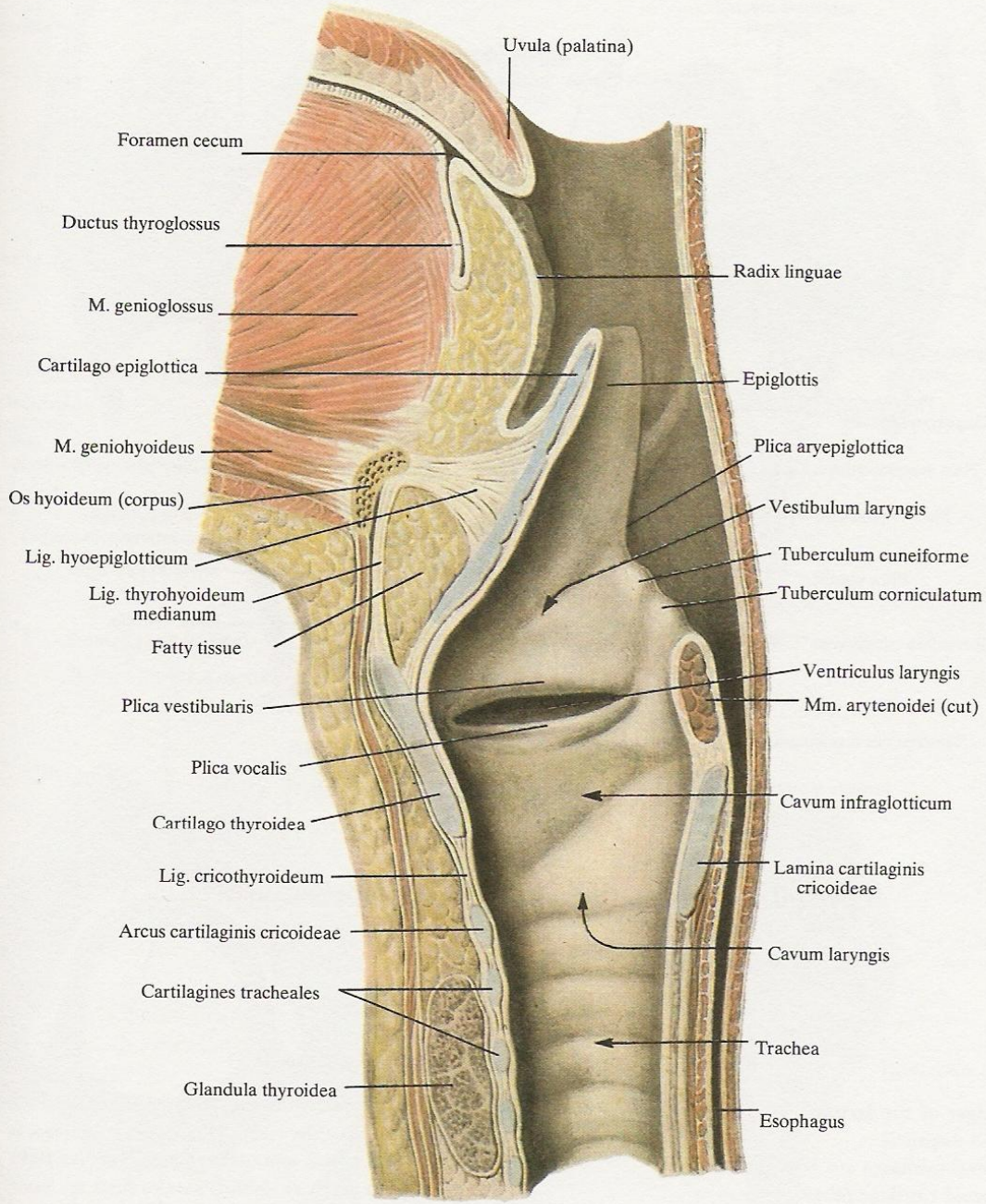
THE LARYNX

The **larynx** *(larynx)* (Figs 494 A, 494 B; 495) is situated in the neck between the levels of the fourth-fifth and sixth-seventh cervical vertebrae and is partly covered in front by the infrahyoid muscles. On each side and partly in front it is in contact with the thyroid gland; posteriorly it is related to the laryngeal part of the pharynx.

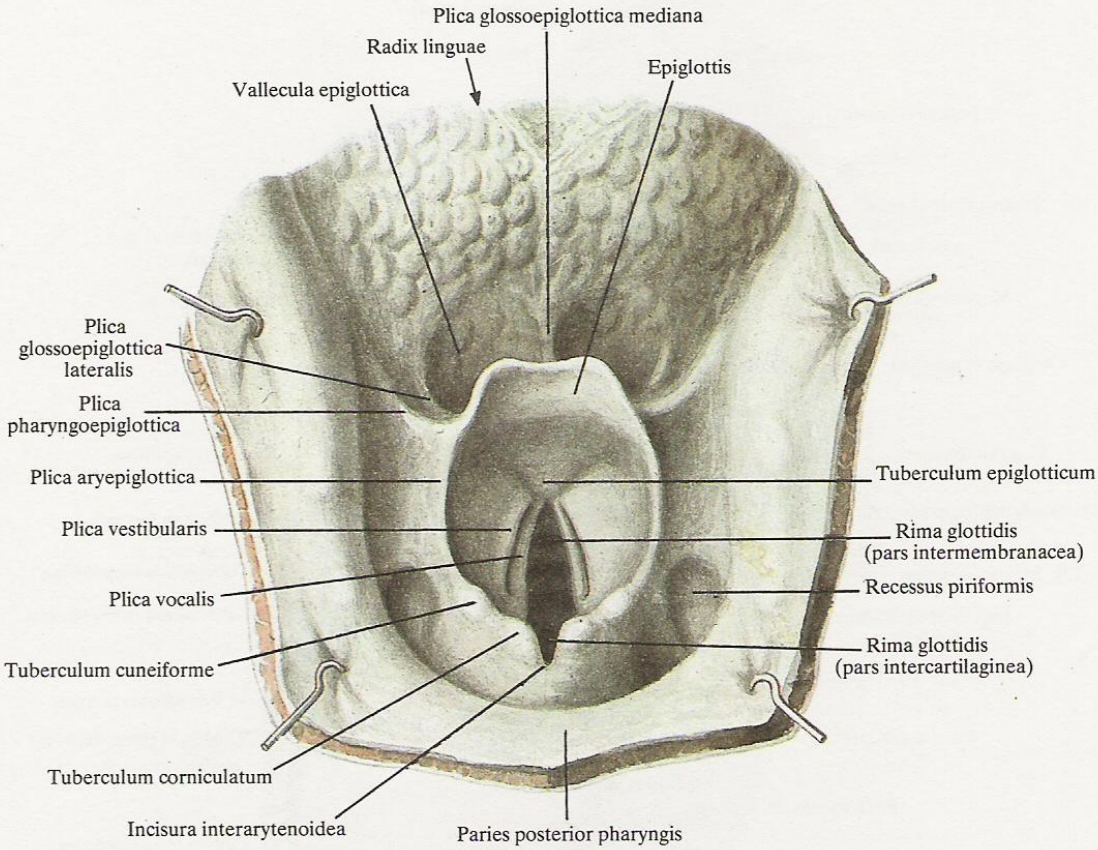
The larynx is joined to the hyoid bone by the thyrohyoid membrane *(membrana thyrohyoidea)* (Fig. 503) and changes position when the bone is displaced by contraction of the supra- and infrahyoid muscles (e. g. in swallowing).

The larynx of a male is larger than that of a female, which is evident particularly in the period of puberty and later.

Cartilages form the firm skeleton of the larynx.



494B. *Cavity of larynx (cavum laryngis);* right side ($^3/_2$).



495. *Inlet of larynx (aditus laryngis);* superior aspect ($^3/_2$).

THE CARTILAGES OF THE LARYNX

The **cartilages of the larynx** *(cartilagines laryngis)* are divided into paired and unpaired.

The unpaired cartilages are as follows:

(1) the thyroid cartilage *(cartilago thyroidea)*;

(2) the cricoid cartilage *(cartilago cricoidea)*;

(3) the epiglottic cartilage *(cartilago epiglottica)*.

The following are the paired cartilages:

(1) the arytenoid cartilages *(cartilagines arytenoideae)*;

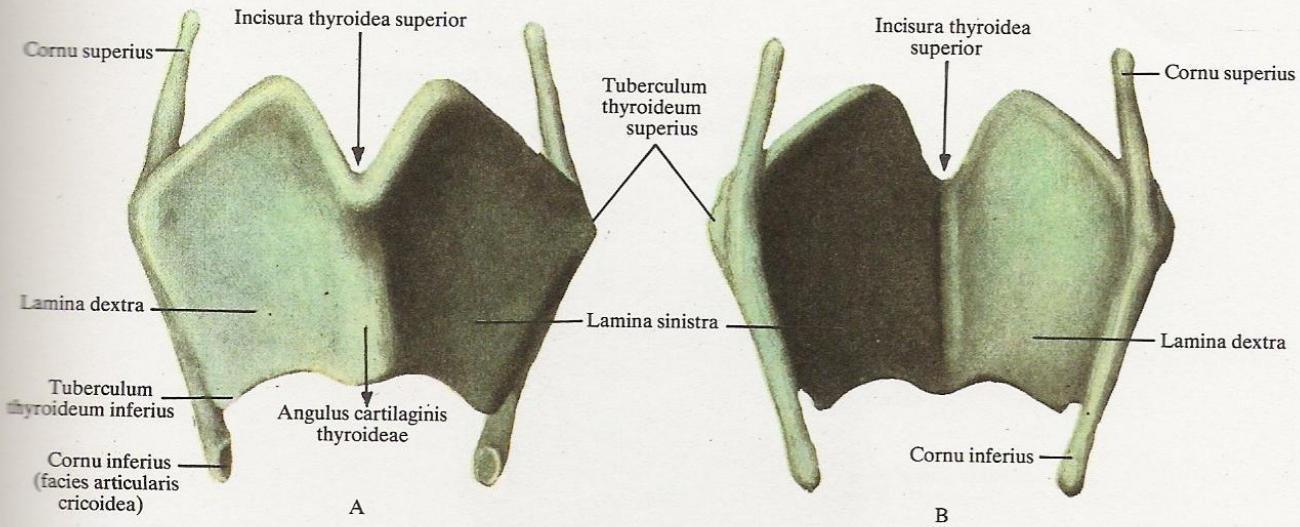
(2) the corniculate cartilages *(cartilagines corniculatae)*;

(3) the cuneiform cartilages *(cartilagines cuneiformes)*.

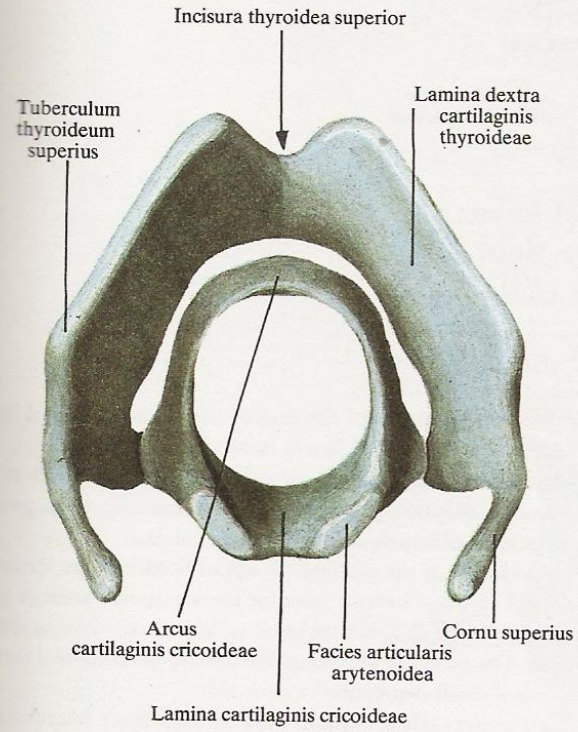
Most of the cartilages of the larynx are hyaline; the epiglottic, corniculate, and cuneiform cartilages as well as the vocal process of each arytenoid cartilage are elastic cartilages. The hyaline cartilages of the larynx may ossify by old age.

1. The **thyroid cartilage** *(cartilago thyroidea)* (Figs 496, 497, 499) is situated above the arch of the cricoid cartilage. It is shaped like a shield whose two symmetrical quadrangular **right** and **left laminae** (*laminae dextra* et *sinistra*) fuse to form an angle with the sides diverging to the back.

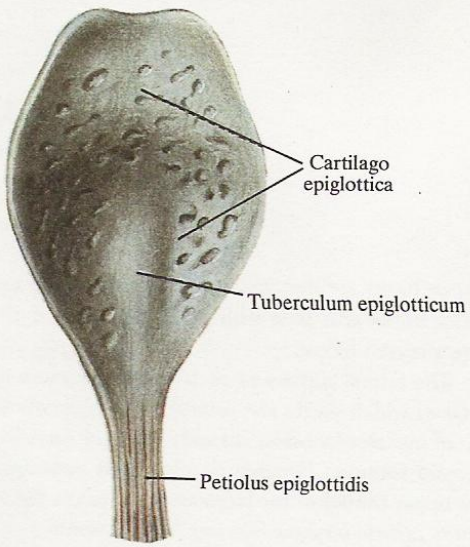
The upper border of the angle protrudes forwards more than the inferior border and bears the **thyroid notch** *(incisura thyroidea superior)*. This part of the cartilage, which is easily felt through the skin, is called the **laryngeal prominence** *(prominentia laryngea)*. The deeper situated **inferior thyroid notch** *(incisura thyroidea inferior)* is on the lower border of the thyroid cartilage. The posterior free end of each lamina is thick and gives off processes, one directed upwards and the other downwards, which are called, respectively, the **superior** and **inferior horns** (*cornu superius* et *cornu inferius*). The su-



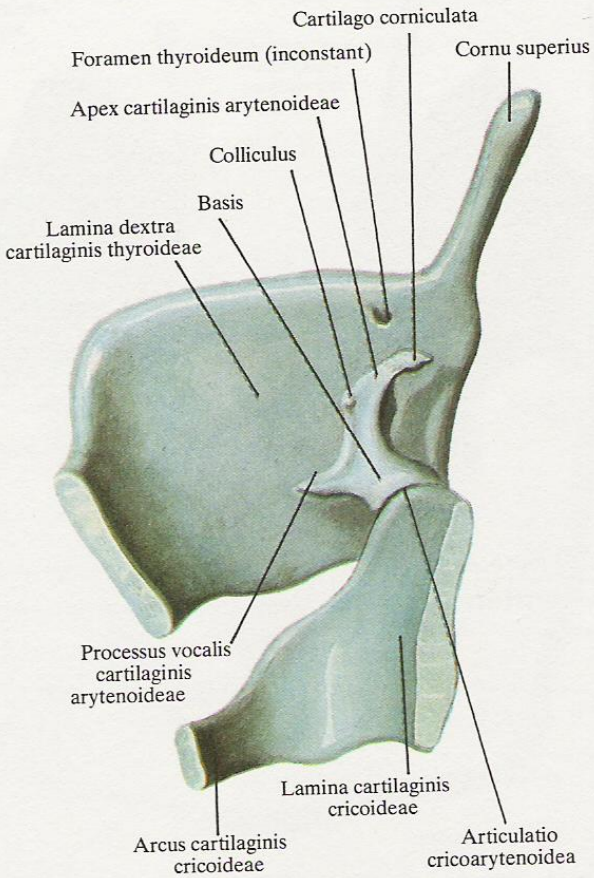
496. *Thyroid cartilage (cartilago thyroidea)* ($^1/_1$).
A—anterior aspect; B—posterior aspect



497. *Thyroid cartilage (cartilago thyroidea) and cricoid cartilage (cartilago cricoidea);* superior aspect ($^3/_2$).



498. *Epiglottic cartilage (cartilago epiglottica);* posterior aspect ($^3/_2$).



499. *Cartilages of larynx (cartilagines laryngis);* right side, medial aspect ($^3/_2$).

perior horns are directed at the hyoid bone situated above, the inferior horns articulate with the lateral surface of the cricoid cartilage situated below.

The lateral surface of each lamina bears an **oblique line** *(linea obliqua)* which marks the insertion of the sternothyroid and thyrohyoid muscles (*musculus sternothyroideus* et *musculus thyrohyoideus*). A **thyroid foramen** *(foramen thyroideum)* is sometimes found close to the upper border of the laminae; it transmits the superior laryngeal artery *(arteria laryngea superior)* (which usually penetrates the thyrohyoid membrane).

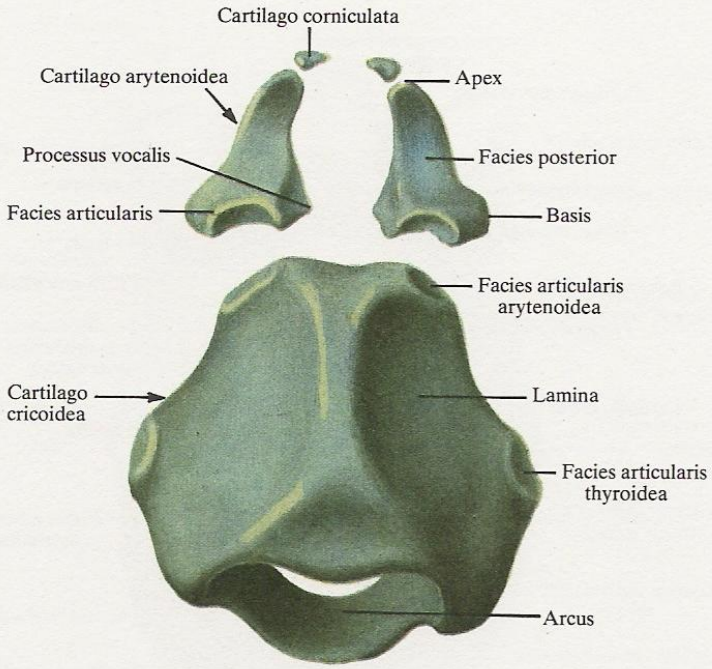
2. The **cricoid cartilage** *(cartilago cricoidea)* (Figs 497, 500–502) is an unpaired cartilage of the larynx which resembles a signet ring in shape (Gk *krikos* ring). Its broader part is directed to the back and is called the **lamina of the cricoid cartilage** *(lamina cartilaginis cricoideae)* while the narrowed part is directed forwards and is known as the **arch of the cricoid cartilage** *(arcus cartilaginis cricoideae).* The lower border of the cricoid cartilage is directed at the first tracheal cartilage and lies horizontally.

The upper border of the cricoid cartilage is parallel to the lower border only along the anterior semicircumference, posteriorly it ascends obliquely and bounds the lamina.

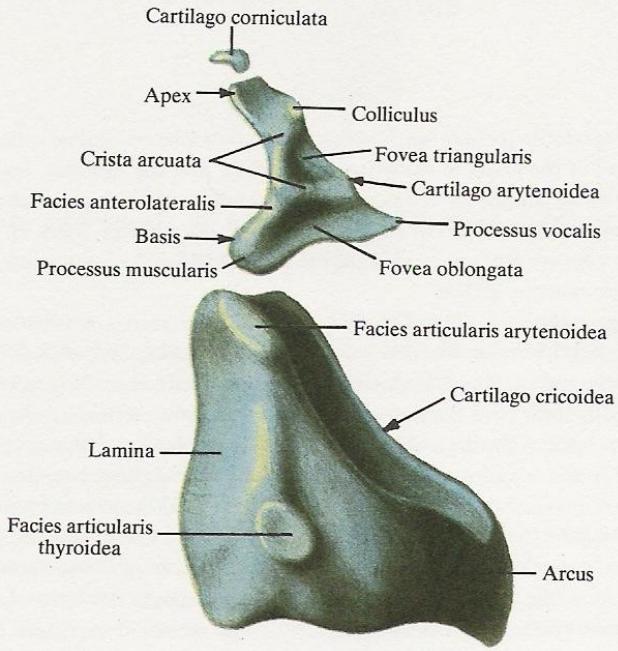
To each side of the midline the upper border of the lamina of the cricoid cartilage bears a **facet for the arytenoid cartilage** *(facies articularis arytenoidea)* for articulation with the base of the arytenoid cartilage. The posterior surface of the lamina has a vertical median crest with a small depression to each side.

Each lateral surface of the cricoid cartilage has a rounded **facet for the thyroid cartilage** *(facies articularis thyroidea)* for articulation with the inferior horn of the thyroid cartilage.

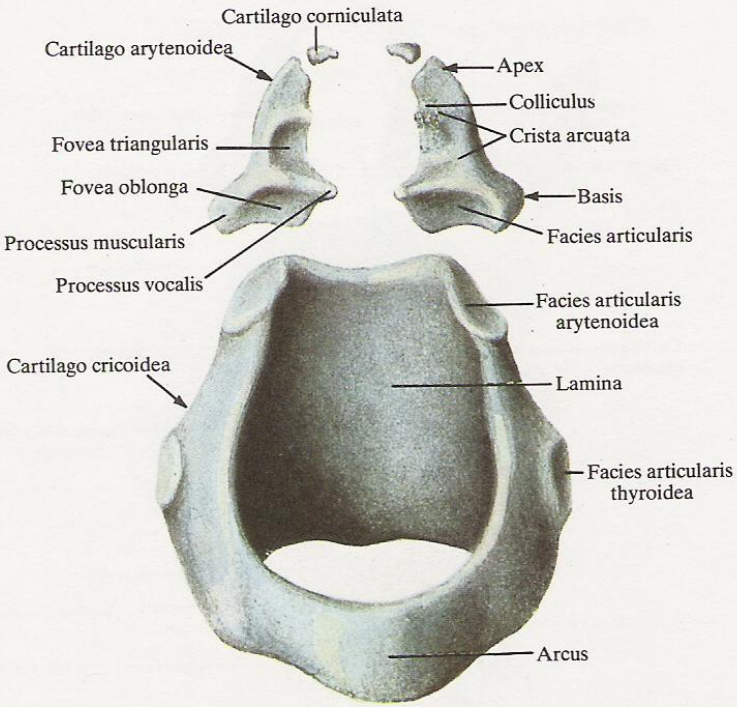
3. The **epiglottic cartilage** *(cartilago epiglottis)* (Figs 498, 504–513, 515) is unpaired, elastic, and protrudes above the superior thyroid notch; it is shaped like the leaf of a tree. Its narrow



500. *Cartilages of larynx (cartilagines laryngis);* posterior aspect ($^3/_2$).



501. *Cartilages of larynx (cartilagines laryngis);* lateral aspect ($^3/_2$).



502. *Cartilages of larynx (cartilagines laryngis);* anterior aspect ($^3/_2$).

lower part is called the **stalk of the epiglottis** *(petiolus epiglottidis)* and is attached to the posterior surface of the angle of the thyroid cartilage, slightly inferior to the notch, by means of a ligament. The wide upper part is situated to the back of and below the root of the tongue. The posterior, slightly concave surface of the epiglottic cartilage bears small pits lodging mucous glands.

4. The **arytenoid cartilage** *(cartilago arytenoidea)* (Figs 499–502, 504, 509, 511, 513, 514) is paired and has the shape of an irregular trihedral pyramid. The **base of the arytenoid cartilage** *(basis cartilaginis arytenoideae)* which articulates with the upper border of the lamina of the cricoid cartilage, and the **apex of the arytenoid cartilage** *(apex cartilaginis arytenoideae)* directed upwards, backwards, and medially, are distinguished.

The **posterior surface** *(facies posterior)* of the cartilage is broad and has an anterior concavity (in the vertical plane). The **medial surface** *(facies medialis)* is small and faces the contralateral arytenoid cartilage. The **anterolateral surface** *(facies anterolateralis)* carries in its upper part a small elevation called the **colliculus** from which an **arcuate crest** *(crista arcuata)* runs downwards and medially. The crest bounds inferiorly the **fovea triangularis**. Below the crest is the **fovea oblonga** into which the vocalis muscle is inserted.

Among the three angles of the base of the arytenoid cartilage, the posterolateral angle, called the **muscular process** *(processus muscularis)*, and the anterior angle, which is called the **vocal process** *(processus vocalis)* are pronounced most. The muscular process is the site of insertion of some of the muscles of the larynx; the vocal process serves for attachment of the vocal ligament and the vocalis muscle.

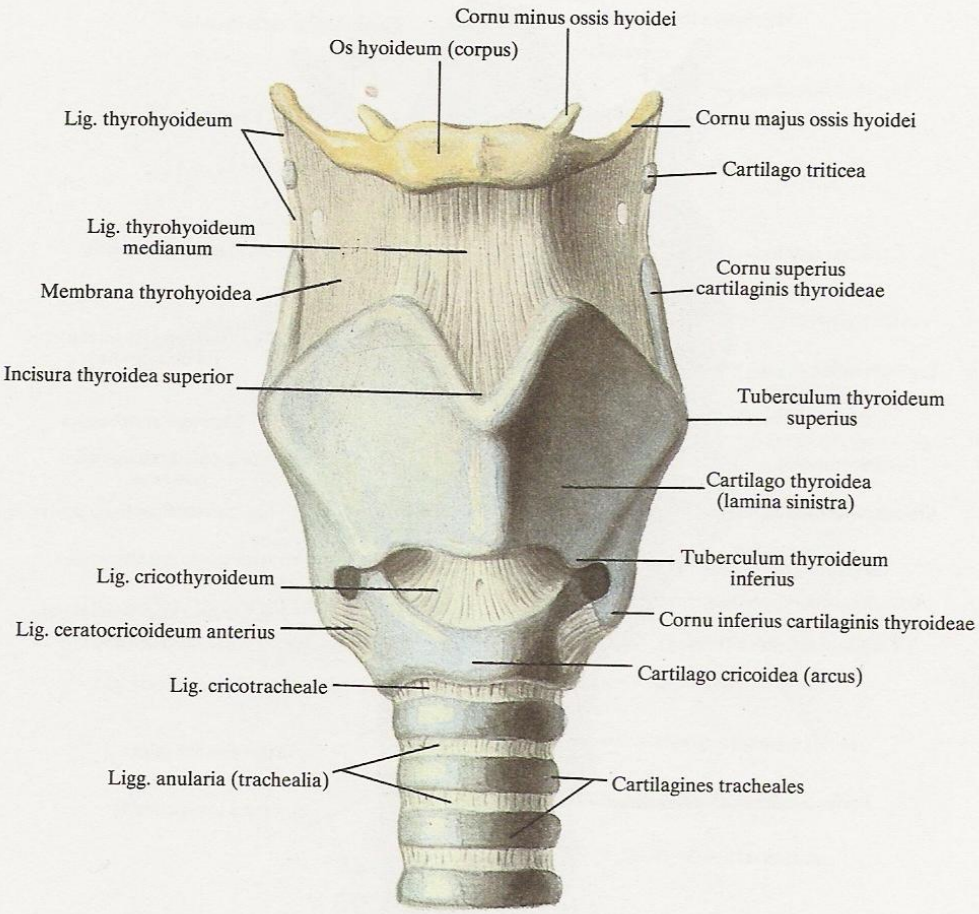
5. The paired **corniculate cartilages** *(cartilagines corniculatae)* (Figs 500–502, 504, 507, 509, 511–514) are small conical structures embedded in the aryepiglottic fold *(plica aryepiglottica)* at the apex of the arytenoid cartilages; each forms the **corniculate tubercle** *(tuberculum corniculatum)* (Fig. 515).

6. The paired **cuneiform cartilages** *(cartilagines cuneiformes)* (Figs 507, 515) are small and wedge-shaped. They are situated in front of and above the corniculate cartilages in the aryepiglottic fold and each forms the **cuneiform tubercle** *(tuberculum cuneiforme)*. These cartilages are often absent.

The **sesamoid cartilages** *(cartilagines sesamoideae)* are small and inconstantly present structures.

Joining of the cartilages of the larynx. The cartilages of the larynx are joined to one another by means of **joints** and **ligaments** (*articulationes* et *ligamenta laryngis*).

The larynx as a whole is connected to the hyoid bone by the



503. *Ligaments and joints of larynx (ligamenta et articulationes laryngis);* anterior aspect ($^1/_1$).

thyrohyoid membrane *(membrana thyrohyoidea)* (Figs 503, 504, 506, 513). This membrane is a broad connective-tissue band stretching between the hyoid bone and the upper border of the thyroid cartilage; it is thickened on the midline to form the **median thyrohyoid ligament** *(ligamentum thyrohyoideum medianum)* (Figs 503, 505). The posterior thickened edge of each side of the membrane which is stretched between the superior horn of the thyroid cartilage and the hyoid bone is called the lateral **thyrohyoid ligament** *(ligamentum thyrohyoideum)* (Figs 503–506). A small sesamoid **cartilago triticea** is often found in the ligament.

The epiglottis is joined to the following structures:

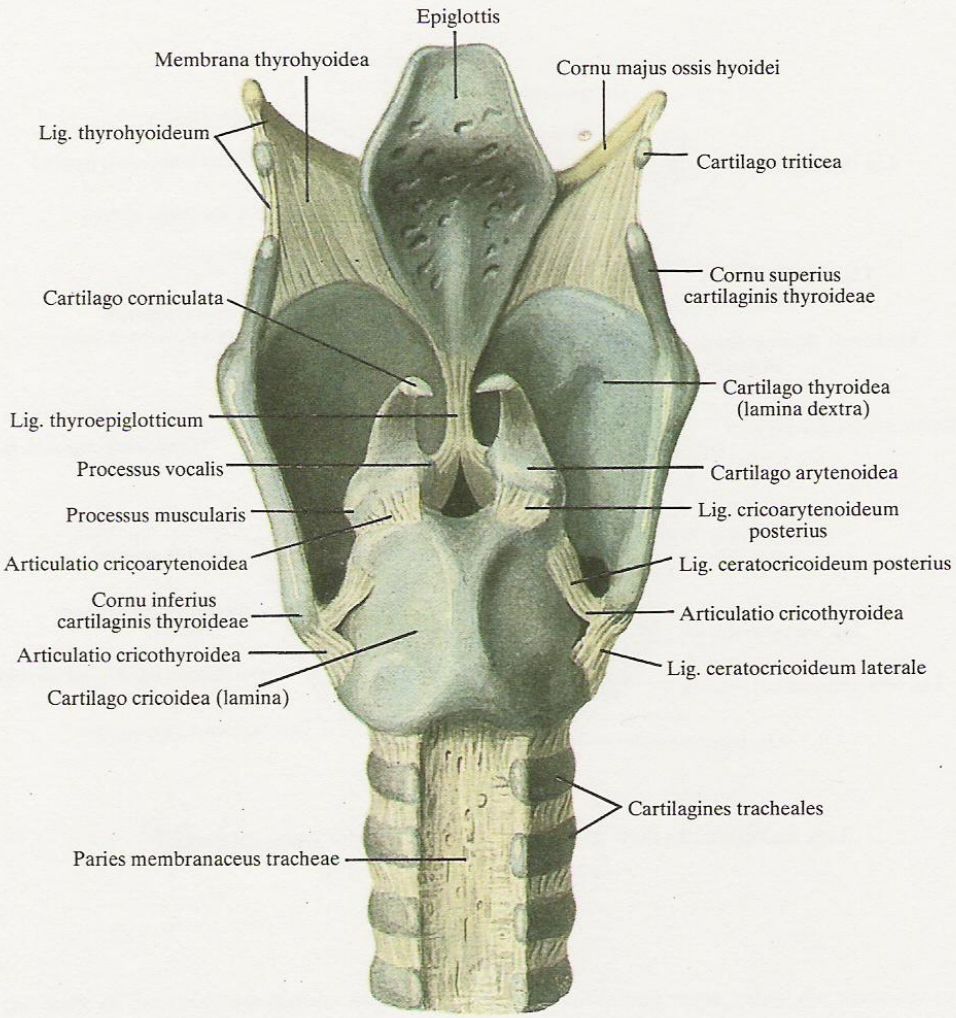
(1) to the body of the hyoid bone by means of the **hyo-epiglottic ligament** *(ligamentum hyoepiglotticum)* (Fig. 505) which runs, gradually narrowing, from the body of the hyoid bone to the anterior surface of the epiglottic cartilage;

(2) to the thyroid cartilage by means of the **thyro-epiglottic ligament** *(ligamentum thyroepiglotticum)* (Figs 504, 511) which is short and stretches from the stalk of the epiglottis to the inner surface of the angle of the thyroid cartilage, slightly inferior to the thyroid notch;

(3) to the superoposterior surface of the root of the tongue by means of three mucosal folds, one median and two lateral. They are called the **glosso-epiglottic fold** *(plica glossoepiglottica mediana)* and **pharyngo-epiglottic folds** *(plicae glossoepiglotticae laterales)* (Fig. 495). Paired depressions called **valleculae epiglotticae** form between the folds.

The cricoid cartilage and the thyroid cartilage are joined as follows:

1. The paired **cricothyroid joint** *(articulatio cricothyroidea)* (Figs 503–505) is formed by the articular facet of the inferior horn



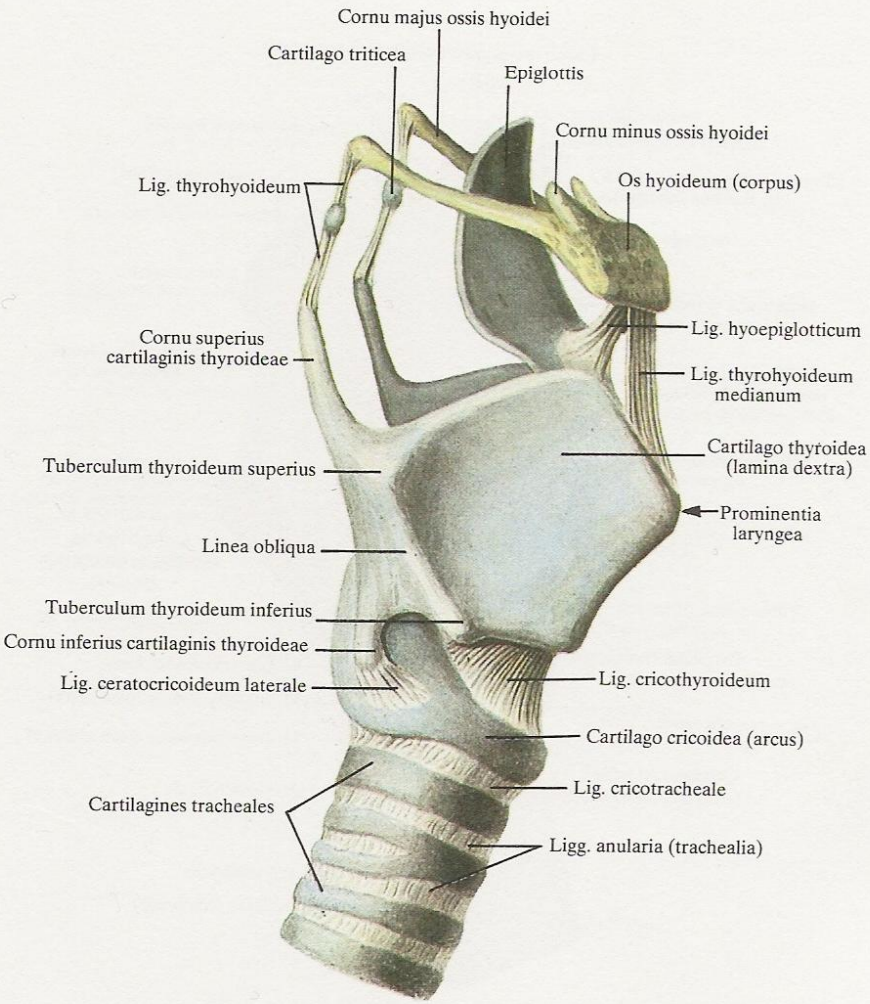
504. *Ligaments and joints of larynx (ligamenta et articulationes laryngis);* posterior aspect ($^1/_1$).

of the thyroid cartilage and the facet for the thyroid cartilage of the cricoid cartilage. The **articular capsule** *(capsula articularis cricothyroidea)* is thin and reinforced by the anterior, posterior, and lateral ceratocricoid ligaments. Movements at this joint occur about the transverse axis, i.e. the thyroid cartilage tilts either forwards or backwards and thus alters its relation with the arytenoid cartilage, as a result of which the vocal ligaments stretching between the vocal process of the arytenoid cartilage and the inner surface of the thyroid cartilage become tense.

2. The **cricothyroid ligament** *(ligamentum cricothyroideum)* (Figs 503, 505) closes the space between the lower border of the thyroid cartilage and the upper border of the arch of the cricoid cartilage. Anteriorly on the midline it is thickened by elastic fibres.

To the back of this ligament is the **elastic membrane of the larynx** *(membrana fibroelastica laryngis)* which stretches to both sides upwards and downwards. Its lower part is called the **cricovocal membrane** *(conus elasticus)* (Figs 513, 514) which is attached to the cricoid cartilage inferiorly and extends to the arytenoid cartilages posteriorly; its free upper border forms the paired **vocal ligament** *(ligamentum vocale)* stretched between the thyroid and arytenoid cartilages (Figs 511, 513, 514).

The cricoid cartilage is joined with the arytenoid cartilage by the **crico-arytenoid joint** *(articulatio cricoarytenoidea)* (Fig. 504). This paired joint forms between the articular facet, the base of the arytenoid cartilage, and the articular facet for the arytenoid cartilage on the cricoid cartilage. Movement of the arytenoid cartilages occurs at this joint which results in their vocal processes swinging away or toward one another.



505. *Ligaments and joints of larynx (ligamenta et articulationes laryngis);* right side ($^1/_1$).

Since the posterior end of the vocal ligaments is attached to the vocal processes, this movement changes the distance between the vocal ligaments.

The corniculate cartilages are joined to the following structures:

(1) the apex of the arytenoid cartilages;

(2) the cricoid cartilage;

(3) an area of the pharyngeal mucous membrane covering the posterior surface of the larynx by means of the **cricopharyngeal ligament** *(ligamentum cricopharyngeum)* (Fig. 512).

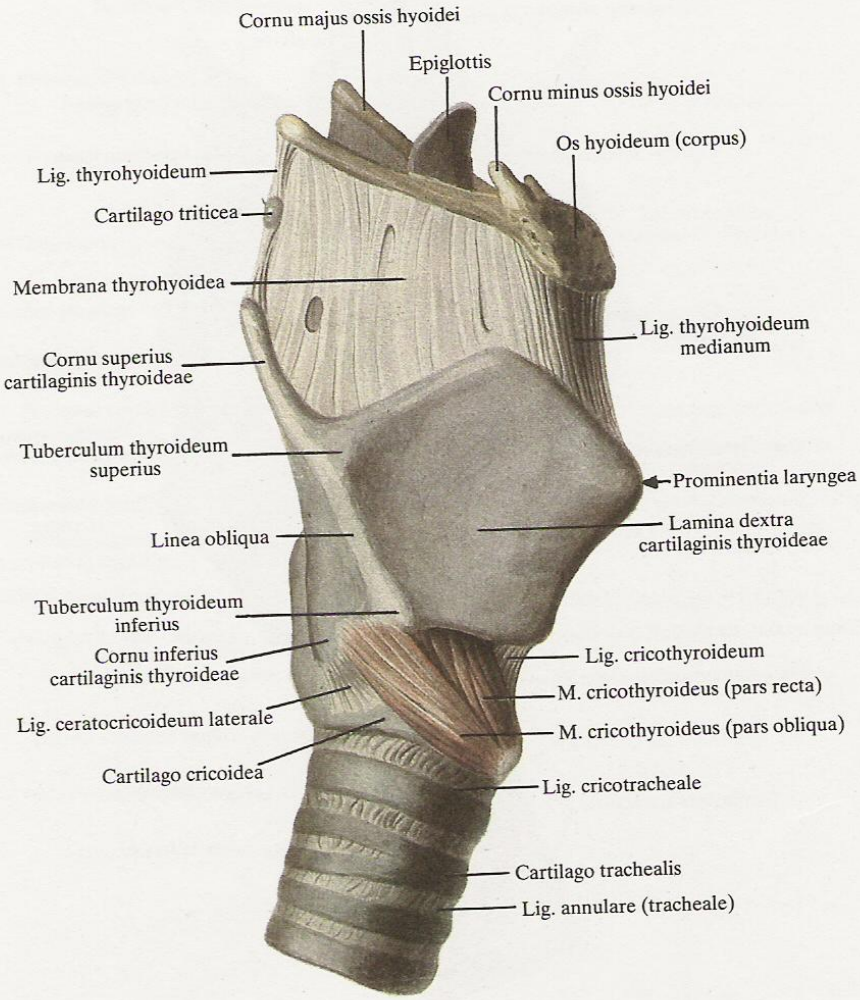
The **cricotracheal ligament** *(ligamentum cricotracheale)* arises from the lower border of the cricoid cartilage and is attached to the upper ring of the trachea (Fig. 507).

Besides the extrinsic (situated on the outer surface) ligaments the larynx has intrinsic ligaments. These are as follows.

1. The paired **vocal ligaments** *(ligamenta vocalia)* (Figs 511, 514) formed of elastic tissue are stretched between the vocal process of the arytenoid cartilage and the inner surface of the angle of the thyroid cartilage on both sides. The vocal ligaments contribute to the formation of the **rima glottidis**.

2. The paired **vestibular ligaments** *(ligamenta vestibularia)* (Figs 511, 513) are developed much less than the vocal ligaments. They are composed of fibrous tissue with a small admixture of elastic fibres.

They are situated proximal and parallel to the vocal ligaments and are also stretched from the arytenoid cartilages (above the vocal process) to the inner surface of the angle of the thyroid cartilage.



506. *Muscles and ligaments of larynx (musculi et ligamenta laryngis);* right side ($^1/_1$).

THE MUSCLES OF THE LARYNX

The **muscles of the larynx** *(musculi laryngis)* are striated; they can be divided into two groups.

1. Muscles responsible for movement of the larynx as a whole.

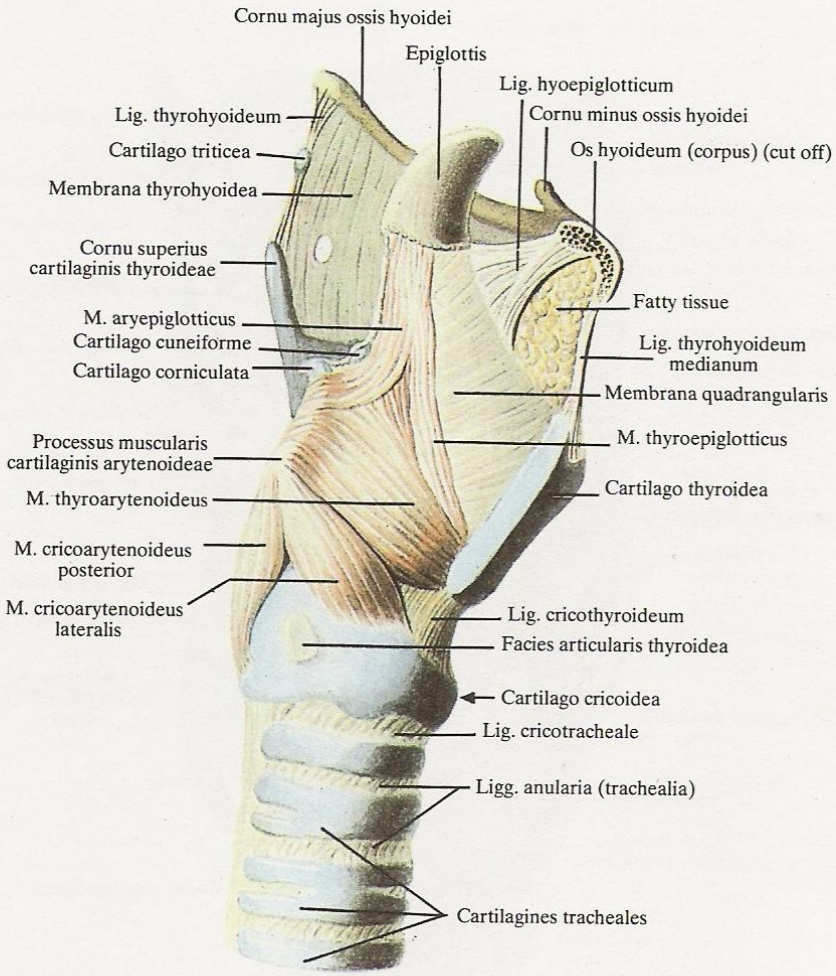
2. Muscles of the larynx proper which determine movement of its individual cartilages.

The first group includes muscles situated on the anterior surface of the neck, which can be divided into supra- and infrahyoid according to their relation to the hyoid bone. They change the position of the hyoid bone and, consequently, of the larynx which is connected to it by the thyrohyoid membrane.

The second group of muscles, which are situated between the cartilages of the larynx, determines the two main functions of the cartilages: (a) the function of the valvular apparatus which changes the position of the epiglottis in the acts of swallowing and respiration and (b) the function of the vocal apparatus, which mainly changes the position of the thyroid and arytenoid cartilages, as a result of which the relation of the vocal ligaments stretched between them also changes.

The following muscles change the position of the epiglottis.

1. The **aryepiglottic muscle** *(musculus aryepiglotticus)* (Figs 507,



507. *Muscles of larynx (musculi laryngis);* right side ($^1/_1$).
(The right plate of the thyroid cartilage is removed.)

508) is poorly pronounced. It arises from the muscular process of the arytenoid cartilage, extends obliquely, crossing its fellow muscle on the posterior surface of the arytenoid cartilages, and passes to the apex of the contralateral arytenoid cartilage. After that it runs anteriorly and fuses with the lateral borders of the epiglottis.

The muscle is covered by a mucous membrane and forms the **aryepiglottic folds** *(plicae aryepiglotticae)* which bind the inlet of the larynx laterally.

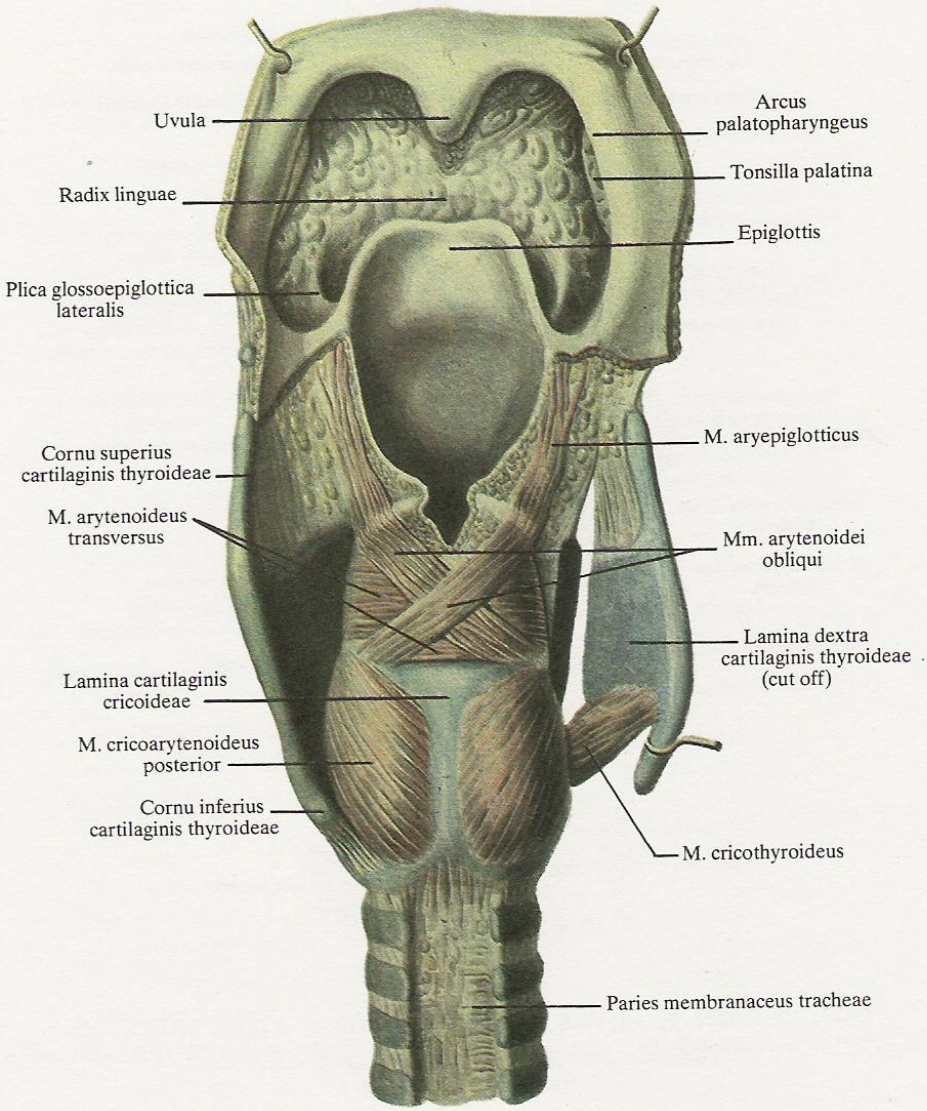
The lower portion of the aryepiglottic muscle between the muscular process and the apex of the contralateral arytenoid cartilage is called the **oblique arytenoid muscle** *(musculus arytenoideus obliquus)*.

On contraction, the aryepiglottic muscle narrows the inlet of the larynx and pulls the epiglottis backwards and downwards and in this way closes the inlet during the act of swallowing.

2. The **thyro-epiglottic muscle** *(musculus thyroepiglotticus)* (Fig. 507) is thin and weak. It arises from the inner surface of the angle of the thyroid cartilage, and runs upwards and to the back to be inserted into the anterior surface of the epiglottis. Its contraction raises the epiglottis and thus opens the inlet of the larynx in breathing and speaking; that is why it is also known as the dilator of the vestibule of the larynx.

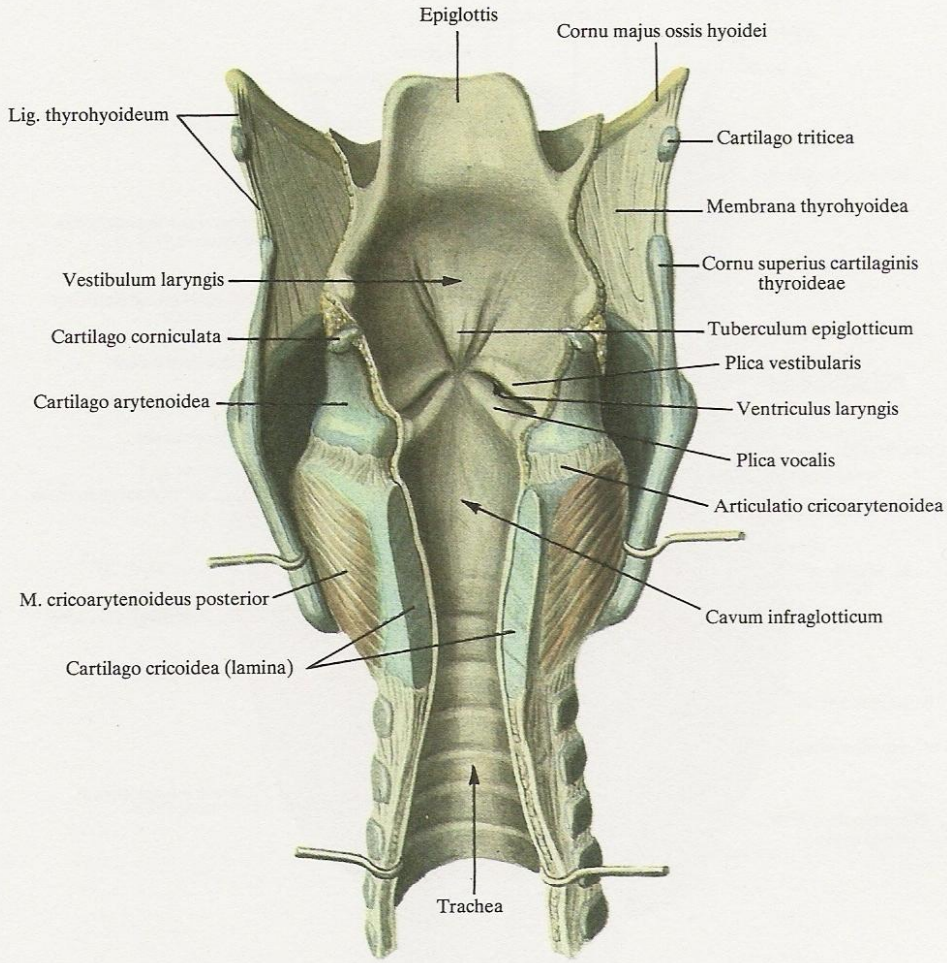
A series of muscles performs the function of the vocal apparatus, according to which they can be grouped as follows:

(a) muscles constricting the rima glottidis *(musculi constrictores rimae glottidis)*;



508. *Muscles of larynx (musculi laryngis);* posterior aspect ($^3/_2$).

(The right plate of the thyroid cartilage is cut and reflected.)



509. *Cavity of larynx (cavum laryngis);* posterior aspect ($^3/_2$).
(The posterior wall of the larynx and trachea is cut.)

(b) muscles dilating the rima glottidis *(musculi dilatatores rimae glottidis)*;

(c) muscles tensing the vocal ligaments;

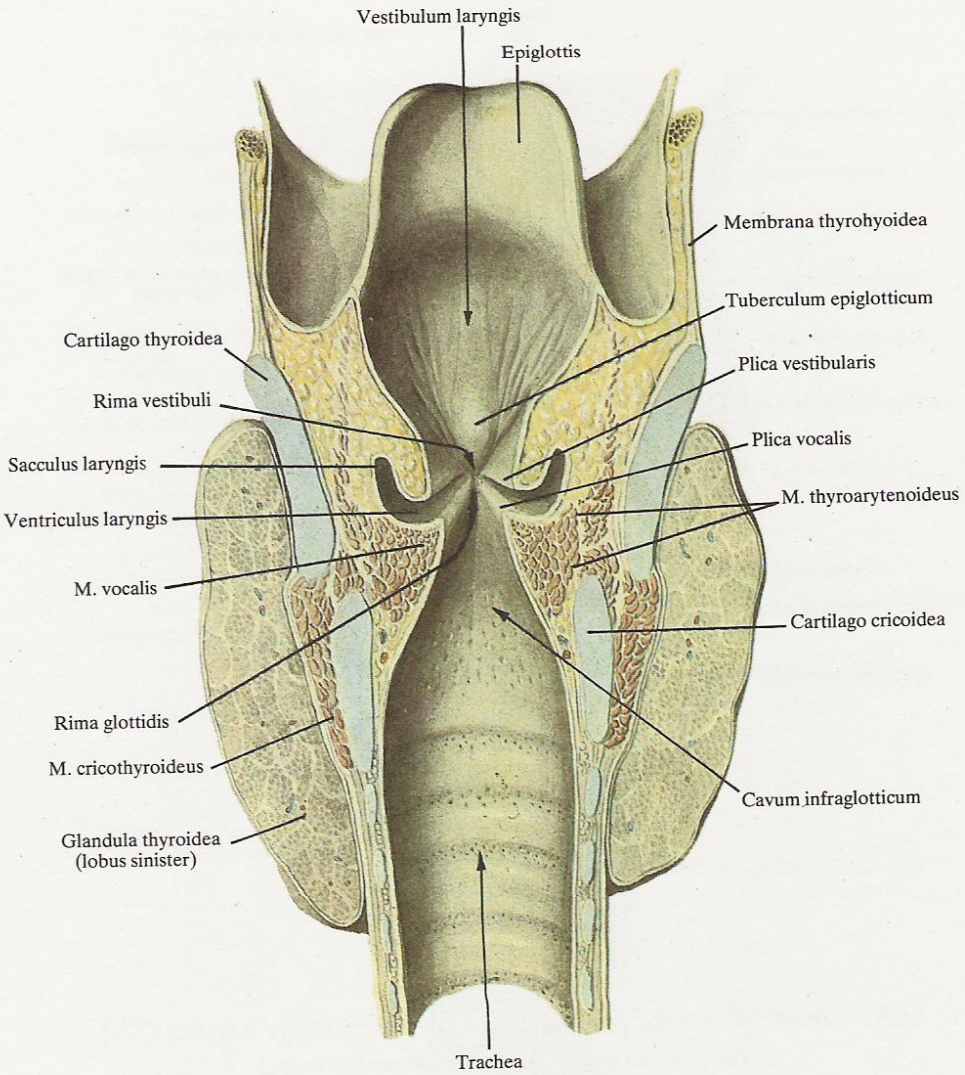
(d) muscles relaxing the vocal ligaments.

Muscles constricting the rima glottidis. 1. The **lateral cricoarytenoid muscle** *(musculus crico-arytenoideus lateralis)* (Fig. 507) arises from the lateral surface of the cricoid cartilage and runs obliquely upwards and to the back to be inserted into the muscular process of the arytenoid cartilage. The muscle pulls the arytenoid cartilage to the side as the result of which the vocal processes of the arytenoid cartilages, and, consequently also the vocal ligaments attached to them, are brought closer to one another and the rima glottidis becomes narrower.

2. The **transverse arytenoid muscle** *(musculus arytenoideus transversus)* (Fig. 508) is unpaired and weak. It stretches between the posterior surfaces of both arytenoid cartilages. Its contraction brings the arytenoid cartilages closer together and thus narrows the rima glottidis, mainly its posterior part.

3. The **vocalis muscle** *(musculus vocalis)* also contributes to constriction of the rima glottidis (see below).

Muscles dilating the rima glottidis. The paired **posterior cricoarytenoid muscle** *(musculus crico-arytenoideus posterior)* (Figs 507–509) arises from the posterior surface of the cricoid cartilage, runs obliquely upwards and laterally, and is inserted into the muscular process of the arytenoid cartilage. It rotates the arytenoid cartilages in such a way that their vocal processes and, conse-



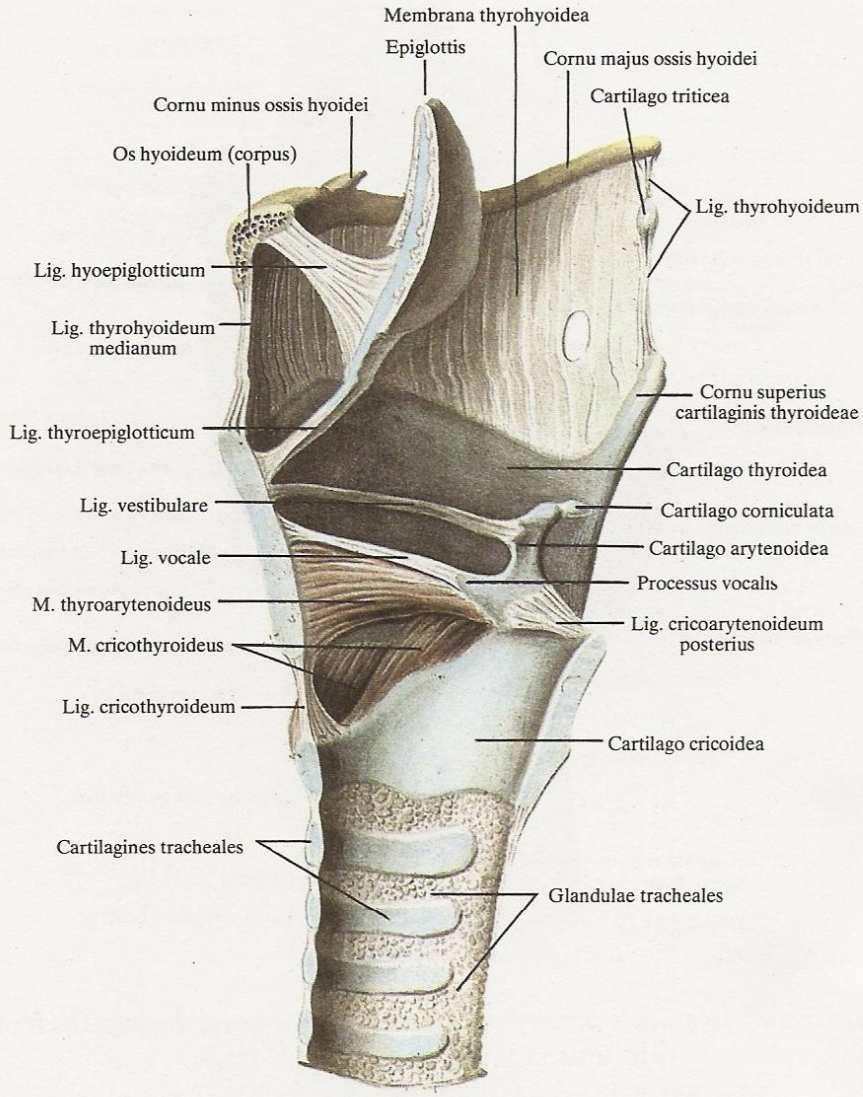
510. *Cavity of larynx (cavum laryngis);* posterior aspect ($^3/_2$).

(Frontal section through middle parts of the vocal ligaments.)

quently the vocal ligaments attached to them, are pulled apart from one another and the rima glottidis becomes wider.

Muscles tensing the vocal ligaments. The paired **crico-thyroid muscle** *(musculus crico-thyroideus)* (Figs 506, 508, 511) lies on the anterolateral surface of the larynx to the sides of the midline. It arises from the arch of the cricoid cartilage, stretches obliquely upwards and laterally, and is inserted into the lower border of the thyroid cartilage for the whole distance to the inferior horn. The muscle has a **straight part** *(pars recta)* which is separated at the inferior thyroid tubercle from the **oblique part** *(pars obliqua)* situated to the back and running almost horizontally. The muscle tilts the thyroid cartilage forwards and thus pulls it further away from the arytenoid cartilage as a result of which the vocal ligaments are tensed.

Muscles relaxing the vocal ligaments. The **thyro-arytenoid muscle** *(musculus thyro-arytenoideus)* lies horizontally in the antero-posterior direction on the inner surface of the thyroid cartilage (Figs 510, 511).



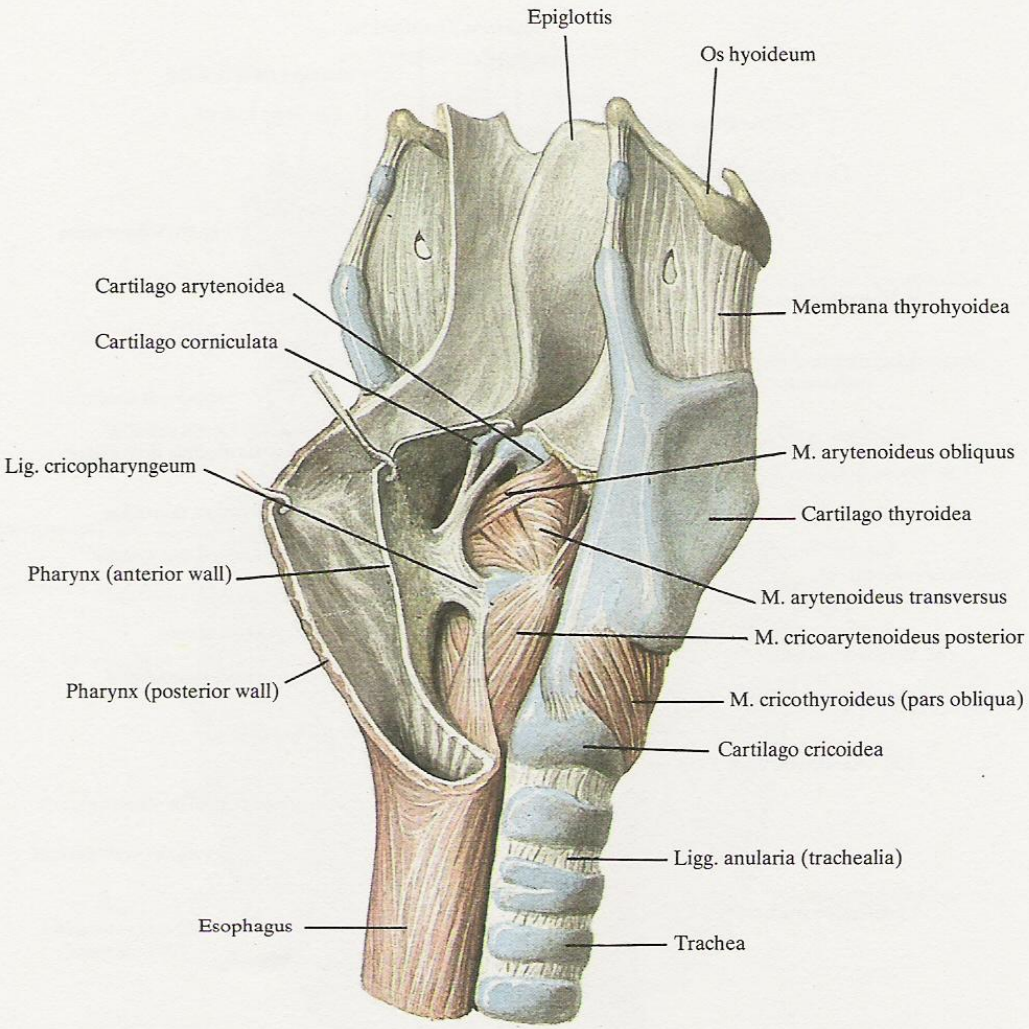
511. *Muscles and ligaments of larynx (musculi et ligamenta laryngis), right side;* inner aspect ($^3/_2$).

(Midsagittal section.)

The lateral part of this muscle arises from the inner surface of the thyroid cartilage to the sides of the midline, extends to the back, and is inserted into the anterolateral surface of the arytenoid cartilage in the region of the crista arcuata and fovea triangularis.

The **vocalis muscle** *(musculus vocalis)* (Fig. 510) lies medially of the thyro-arytenoid muscle. It is a trihedral muscle projecting into the lumen of the larynx and lies within the substance of the vocal fold *(plica vocalis)*. It arises from the inner surface of the thyroid cartilage close to the angle and stretches to the back to be inserted into the vocal process and the fovea oblonga of the arytenoid cartilage.

Contraction of the thyro-arytenoid muscle as a whole relaxes the tensed vocal ligaments and partly narrows the rima glottidis. Within the vestibular fold is a poorly developed muscle stretching from the inner surface of the thyroid cartilage to the arytenoid cartilage. Its contraction alters the tension of the vestibular fold.



512. *Muscles and ligaments of larynx (musculi et ligamenta laryngis);* from right side and slightly to the back ($^5/_4$).

(The cavity of the larynx is opened, its walls are pulled to the back.)

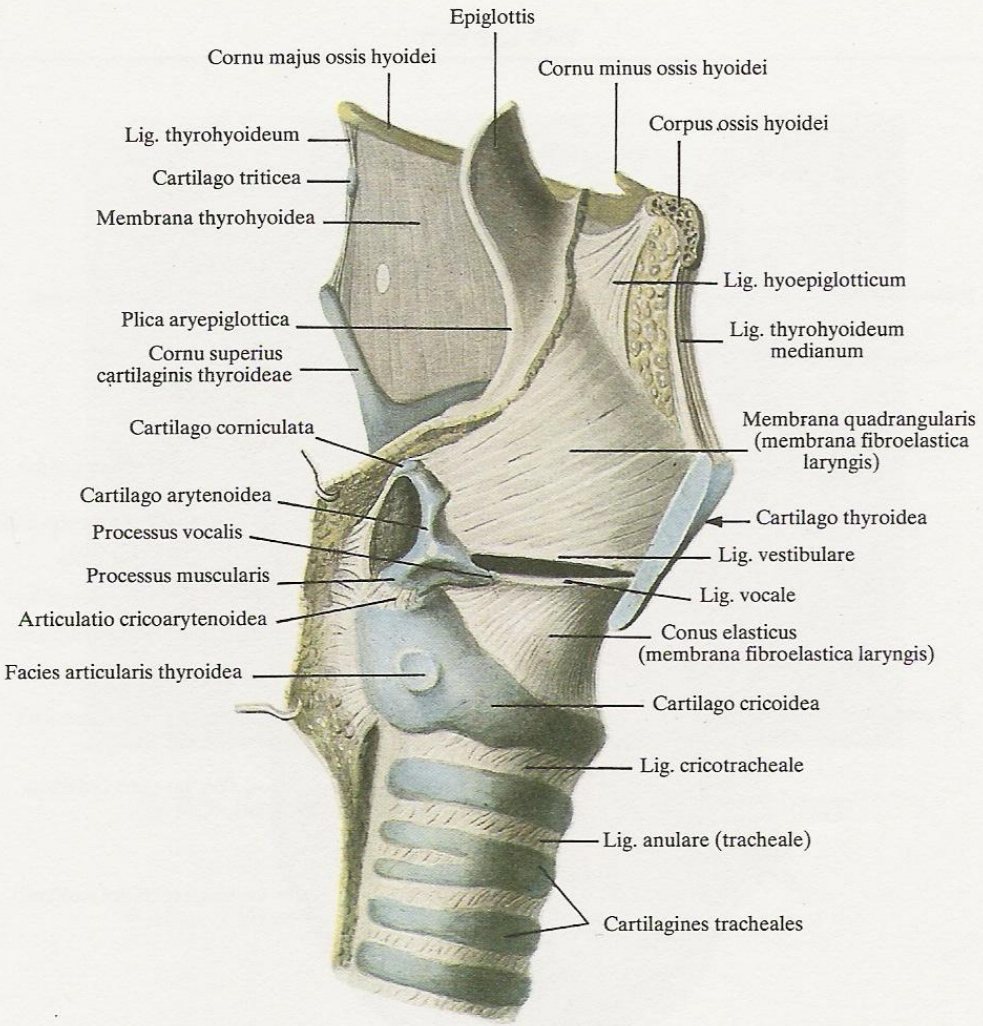
THE MUCOUS COAT OF THE LARYNX

The **mucous coat (membrane) of the larynx** *(tunica mucosa laryngis)* is joined to the cartilages by means of the **elastic membrane of the larynx** *(membrana fibroelastica laryngis)* (Fig. 513) which is the **submucous coat** *(tela submucosa)* consisting of connective tissue with a rich admixture of elastic fibres. Two parts are distinguished in this elastic membrane: the **quadrangular membrane** *(membrana quadrangularis)* (Fig. 513) lying in the anterosuperior part of the larynx, and the **cricovocal membrane** *(conus elasticus)* (Figs 513, 514) situated in the lower part.

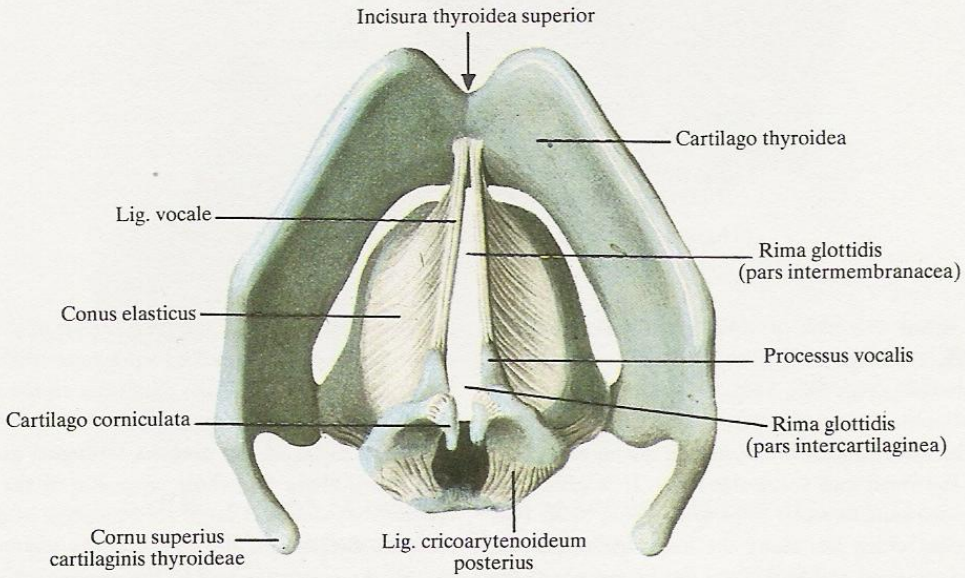
The cricovocal membrane is a continuation of the cricothyroid ligament, and its free upper part takes part in the formation of the **vocal ligament** *(ligamentum vocale)*. The lower border of the quadrangular membrane contributes to the formation of the **vestibular ligament** *(ligamentum vestibulare)*.

The mucous coat of the larynx is at places loosely connected with the cartilages, particularly in the region of the aryepiglottic fold *(plica aryepiglottica)* (Fig. 515) and in the region of the free border of the vocal ligament.

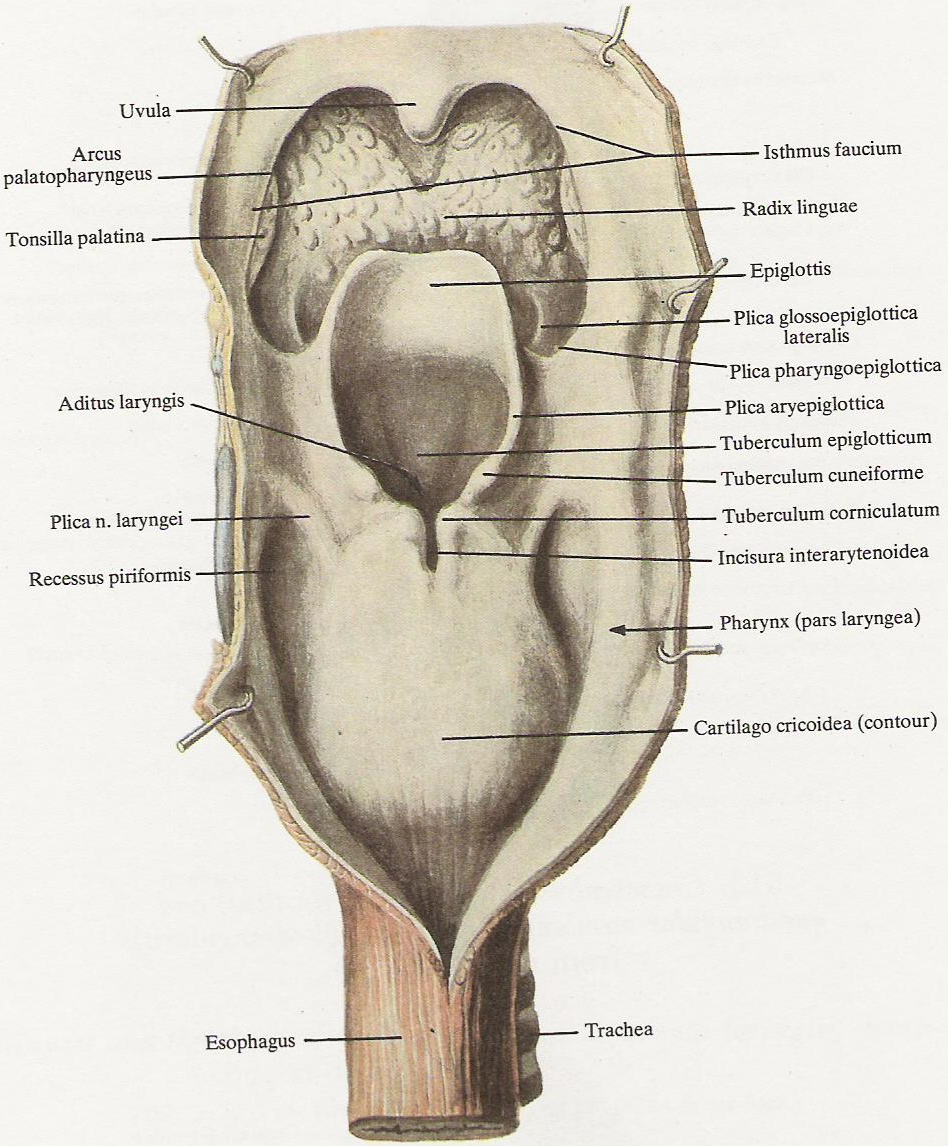
The mucous membrane covering the vestibular ligament forms the upper pair of the **vestibular folds** *(plicae vestibulares)* (Figs 494 B; 495, 509, 510). The mucous membrane covering the free upper border of the conus elasticus, the vocal ligament, and



513. *Cricovocal membrane (conus elasticus) and quadrangular membrane (membrana quadrangularis);* from right side ($^5/_4$).



514. *Cricovocal membrane (conus elasticus) and vocal ligaments (ligamenta vocalia);* superior aspect ($^3/_2$).



515. *Larynx*; posterior aspect (1/1).
(The posterior wall of the larynx is cut and reflected.)

the vocalis muscle forms the pair of **vocal folds** *(plicae vocales)* (Figs 494 B; 495, 509, 510). The cleft between the two vocal folds is called the **rima glottidis** (Figs 495, 514).

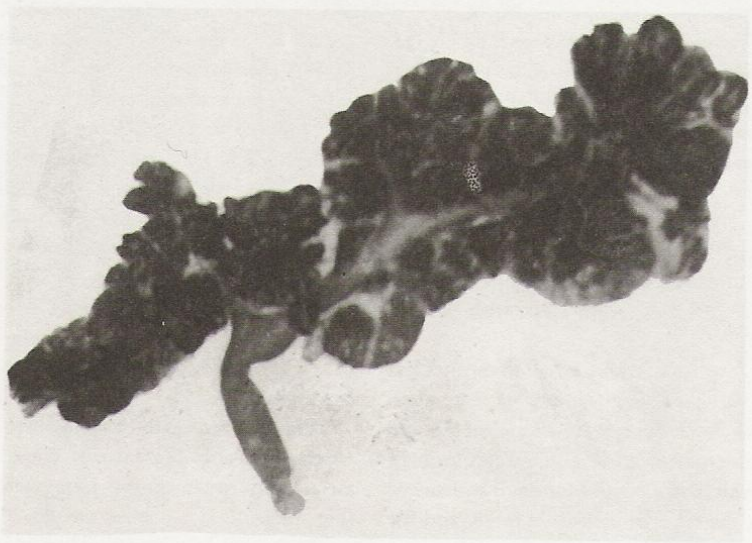
A depression extending under the base of the vestibular ligament is formed on the mucous membrane, on the lateral surface of the larynx between the vocal and vestibular folds. It is called the **sinus of the larynx** *(ventriculus laryngis)* (Figs 494 A, 509, 510). This is a small paired recess which lies along the inner surface of the lamina of the thyroid cartilage and terminates by the **saccule of the larynx** *(sacculus laryngis)* (Fig. 510).

The mucous coat of the greater part of the larynx is covered by ciliated epithelium; stratified squamous epithelium occurs only on the posterior surface of the epiglottis, in the region of the vocal ligament, and on the inner surface of the arytenoid cartilage.

Many ducts of the mucous **laryngeal glands** *(glandulae laryngeae)* open along the whole extension of the mucous coat, except for the vocal folds. A large accumulation of glands is also encountered in the sinus of the larynx in the region of the posterior surface of the epiglottis, and in the aryepiglottic and vestibular folds (Figs 516 A, 516 B).

516A. *Glands of mucous coat of larynx* (specimen prepared by P. Ruzhinsky.) (Photomicrograph.)

(Group of glands from a totally stained mucous coat of the sinus of the larynx.)



516B. *Gland of mucous coat of larynx* (specimen prepared by P. Ruzhinsky).

(Gland isolated from a totally stained mucous coat of the infraglottic cavity.)

THE CAVITY OF THE LARYNX

The **cavity of the larynx** *(cavum laryngis)* (Figs 494 B; 509, 510) is shaped like an hourglass. The upper, wider part is the **vestibule of the larynx** *(vestibulum laryngis)* which stretches from the **inlet of the larynx** *(aditus laryngis)* to the level of the vestibular folds *(plicae vestibulares)*. The inlet is bounded in front by the posterior surface of the epiglottis, behind by the apices of the arytenoid cartilages, and laterally by the aryepiglottic folds *(plicae aryepiglotticae)*. A **piriform fossa** *(recessus piriformis)* is situated on both sides between the aryepiglottic folds and the inner surface of the thyroid cartilage (Fig. 515) (see *The Pharynx*).

The middle, narrower part of the larynx is the vocal apparatus proper and is called the **glottis**. It is bounded above by the vestibular folds and below by the vocal folds and has the shape of a sagittal opening bounded laterally by the two pairs of the mentioned folds. The opening between the vestibular folds is called the **rima vestibuli**, that between the vocal folds is the **rima glottidis**. Two parts are distinguished in the rima glottidis: (1) the **intermembranous part** *(pars intermembranacea)* situated between the free borders of the vocal folds and (2) the **intercartilaginous part** *(pars intercartilaginea)*, or respiratory part, which is the wider, posterior segment of the rima glottidis extending into the space between the arytenoid cartilages.

That part of the larynx which is below the vocal folds is called the **infraglottic cavity** *(cavum infraglotticum)*; it widens conically downwards to be continuous with the cavity of the trachea.

Innervation: the superior laryngeal nerve *(nervus laryngeus superior)*, the laryngeal branches of the vagus nerve *(nervus laryngeus inferior)*, rami sympathici.

Blood supply: the superior and inferior laryngeal arteries (*arteriae laryngeae superior* et *inferior*).

THE TRACHEA AND THE BRONCHI

On the level of the sixth-seventh servical vertrebrae the larynx is continuous with the **trachea** (Figs 517–520, 523); this level is lower in males and higher in females. The trachea begins in the lower part of the neck where it is called the cervical part and then passes through the inlet of the thorax *(apertura thoracis superior)* into the cavity of the thorax and is now called the thoracic part. Descending, it occupies a median position being in front of the oesophagus and behind the large vessels in the cavity of the thorax. Its length varies from 9 to 15 cm and its breadth from 1.5 to 2.7 cm.

At the level of the fourth thoracic vertebra the trachea divides into the **right** and **left bronchi** (*bronchi principales dexter* et *sinister*). The place of the division is called the **bifurcation of the trachea** *(bifurcatio tracheae)*. Inside it has a keel-like projection into the trachea which is known as the **carina of the trachea** *(carina tracheae)* (Fig. 519).

The bronchi diverge asymmetrically: the right bronchus is shorter (3 cm) but wider, and arises from the trachea at an obtuse angle (the azygos vein curves over it); the left bronchus is longer (4–5 cm), narrower, and forms an almost right angle with the trachea (the aorta passes over it).

The framework of the trachea and right and left bronchi is formed by incomplete rings of cartilages *(cartilagines tracheales)*; their ends are united by means of a connective-tissue membrane forming the posterior wall of the trachea and right and left bronchi and called the **membranous wall** *(paries membranaceus)*. The trachea is formed of 16–20 cartilages, the right bronchus–of 6—8, and the left bronchus of 9–12 cartilages. The cartilages are joined to one another by means of **annular ligaments** *(ligamenta anularia)* which are continuous posteriorly with the membranous wall of the trachea and bronchi. The membranous wall also contains smooth muscle fibres which run longitudinally and transversely to form the **tracheales muscles** *(musculi tracheales)*.

The inner surface of the trachea and bronchi is lined with the **mucous coat (membrane)** *(tunica mucosa)* which is connected to the cartilages rather loosely by the **submucous coat** *(tela submucosa)*.

The mucous coat of the trachea is devoid of folds and is covered, just like that of the larynx, by stratified ciliated epithelium containing many **tracheal glands** *(glandulae tracheales)* (Fig. 520); the mucous membrane of the bronchi contains **bronchial glands** *(glandulae bronchiales)* (Fig. 527). Most of the tracheal and bronchial glands are embedded in the submucous coat in the region of the intercartilaginous spaces and the membranous wall, while a lesser number is situated behind the cartilages.

Each bronchus enters the corresponding lung in which it gives off branches to form the bronchial tree.

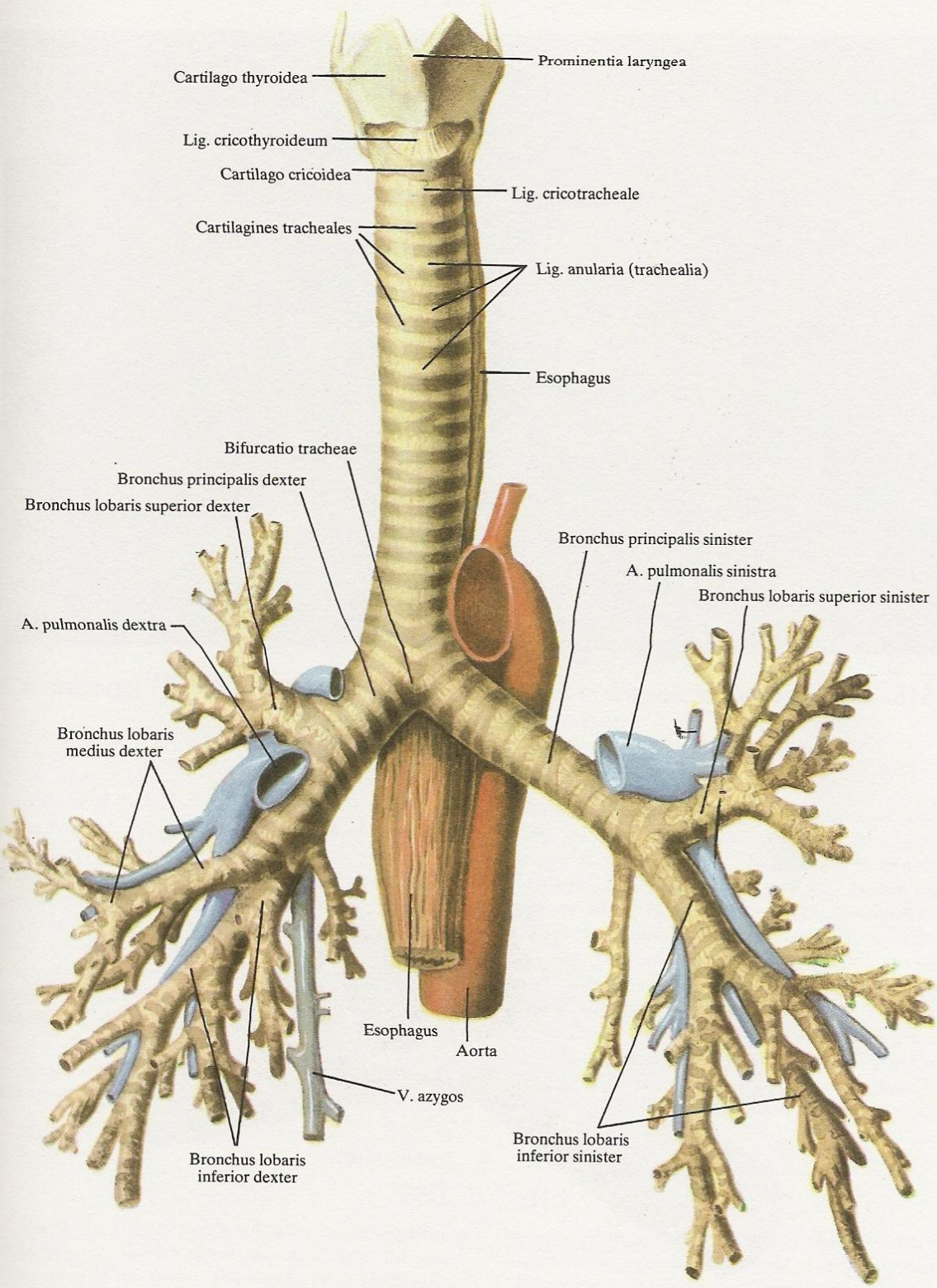
The right bronchus gives off three branches, one of which passes above and the other two below the artery. The left bronchus gives rise to two branches which are situated below the artery.

Each branch supplies air to the lobes of the lungs. In each lung the bronchi divide further on, their branches reduce in diameter and are continuous with small bronchi containing neither cartilages nor glands. Small branchings about 1 mm in diameter are called **lobular bronchi** *(bronchi lobulares)*, which give off 12 to 18 end bronchioles.

The end bronchioles divide into **respiratory**, or **terminal bronchioles** *(bronchioli respiratorii)*. These terminal bronchioles transmit air to tiny areas of the lung which are called acini (L *grape*) (Fig. 526).

In the acini the terminal bronchioles branch out, become wider and give rise to 2–9 **alveolar ducts** *(ductuli alveolares)* whose wall bulges out to form the **alveoli of the lungs** *(alveoli pulmonis)*.

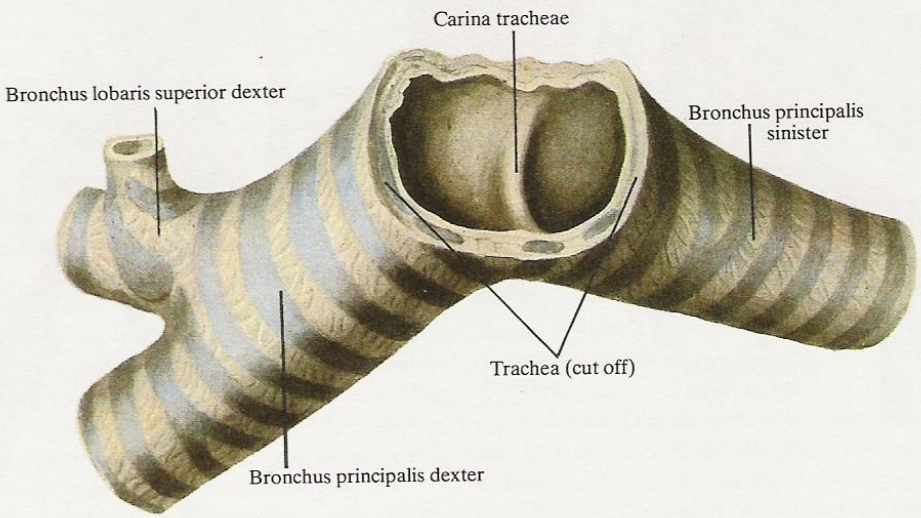
The total number of alveoli in each lung comes to hundreds millions; the total area of their respiratory surface measures tens of square metres.



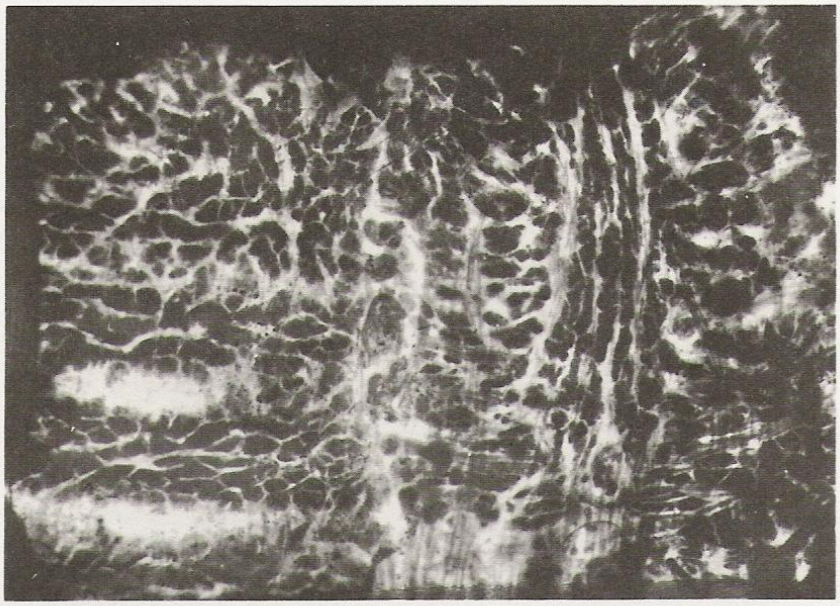
517. *Trachea and bronchi*; anterior aspect (¾).

518. *Cartilaginous framework of lower parts of trachea and bronchi* (1/1) (specimen prepared by K. Filatova).

(Totally stained specimen.)



519. *Bifurcation of trachea (bifurcatio tracheae);* superior aspect (3/2).



520. *Glands of trachea* (specimen prepared by Ya. Sinelnikov). (Photomicrograph.)

(Group of glands from a totally stained wall of an intact trachea; region of membranous wall and cartilaginous and intercartilaginous spaces.)

The structure of the bronchi walls changes with their branching. The cartilaginous framework of the right and left bronchi constitutes two-thirds of the circumference on the average, the walls of smaller bronchial branches, in contrast, contain only very small cartilaginous patches of various shape. With the gradual decrease of cartilaginous tissue in the wall of the bronchial branches, the amount of connective tissue in them increases. The bronchioles are devoid of cartilaginous tissue but contain smooth circular muscle fibres in their wall. The wall of an alveolus contains elastic fibres and has a rich network of blood capillaries on its surface.

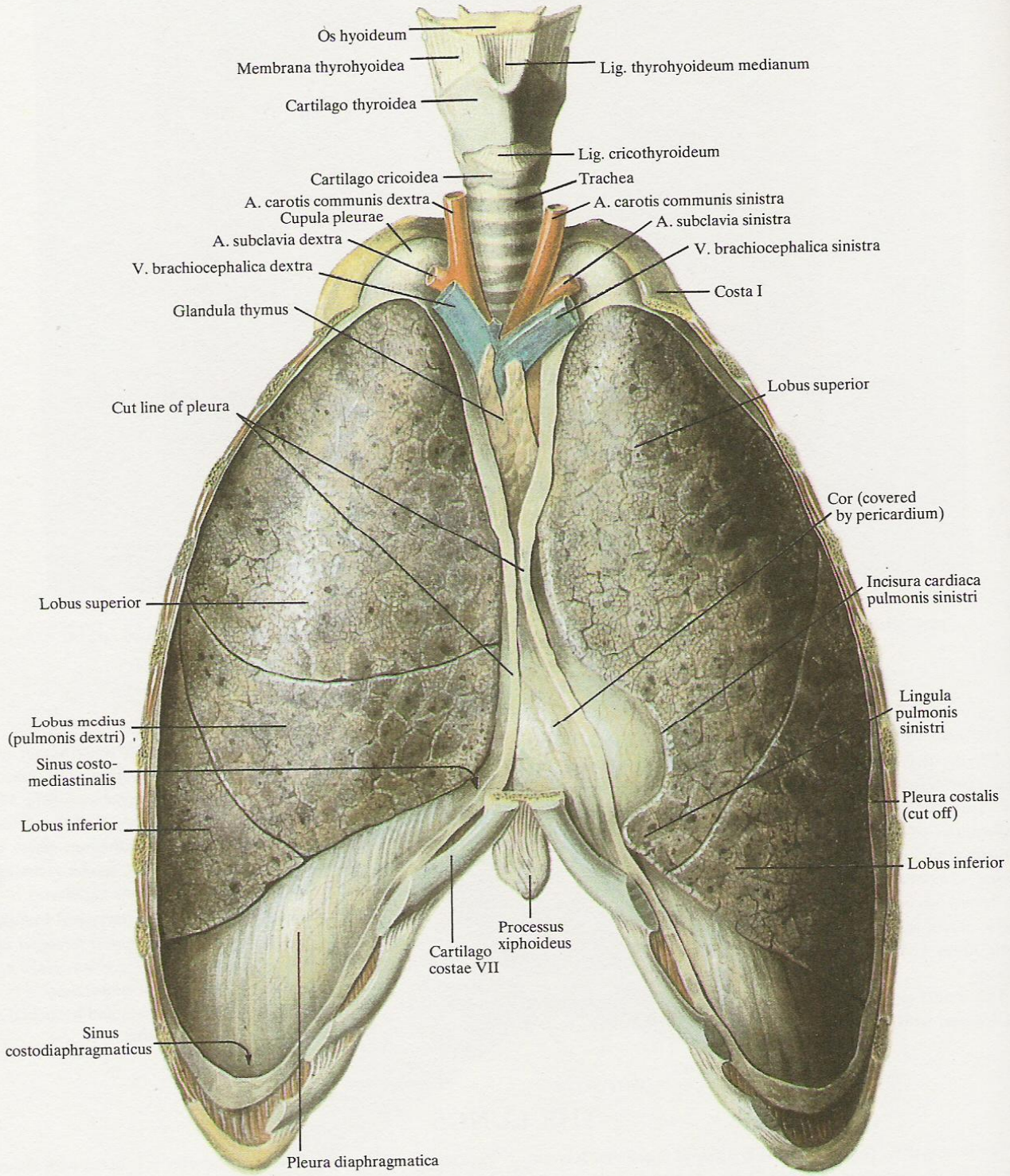
The branches of the bronchial tree are lined with a mucous coat covered with stratified ciliated columnar epithelium which is gradually replaced in the smaller branches by double-layer and, finally, by single-layer cubical ciliated epithelium. The mucous coat is rich in **bronchial glands** *(glandulae bronchiales)* (Fig. 527). The glands are absent in the bronchioles. The wall of the alveolar ducts and alveoli is covered by respiratory epithelium which has the appearance of fine anucleate or, at places, nuclei-containing laminae surrounded by a thick network of blood capillaries.

Innervation: the recurrent laryngeal nerve (laryngeal branches of the vagus nerve) *(nervus laryngeus recurrens, nervus laryngeus inferior)*, pulmonary branches of the vagus nerve (*rami bronchiales anteriores* et *posteriores*), sympathetic trunk *(truncus sympathicus)*.

Blood supply: tracheal, mediastinal branches and bronchial arteries *(rami tracheales, mediastinales, et bronchiales)*.

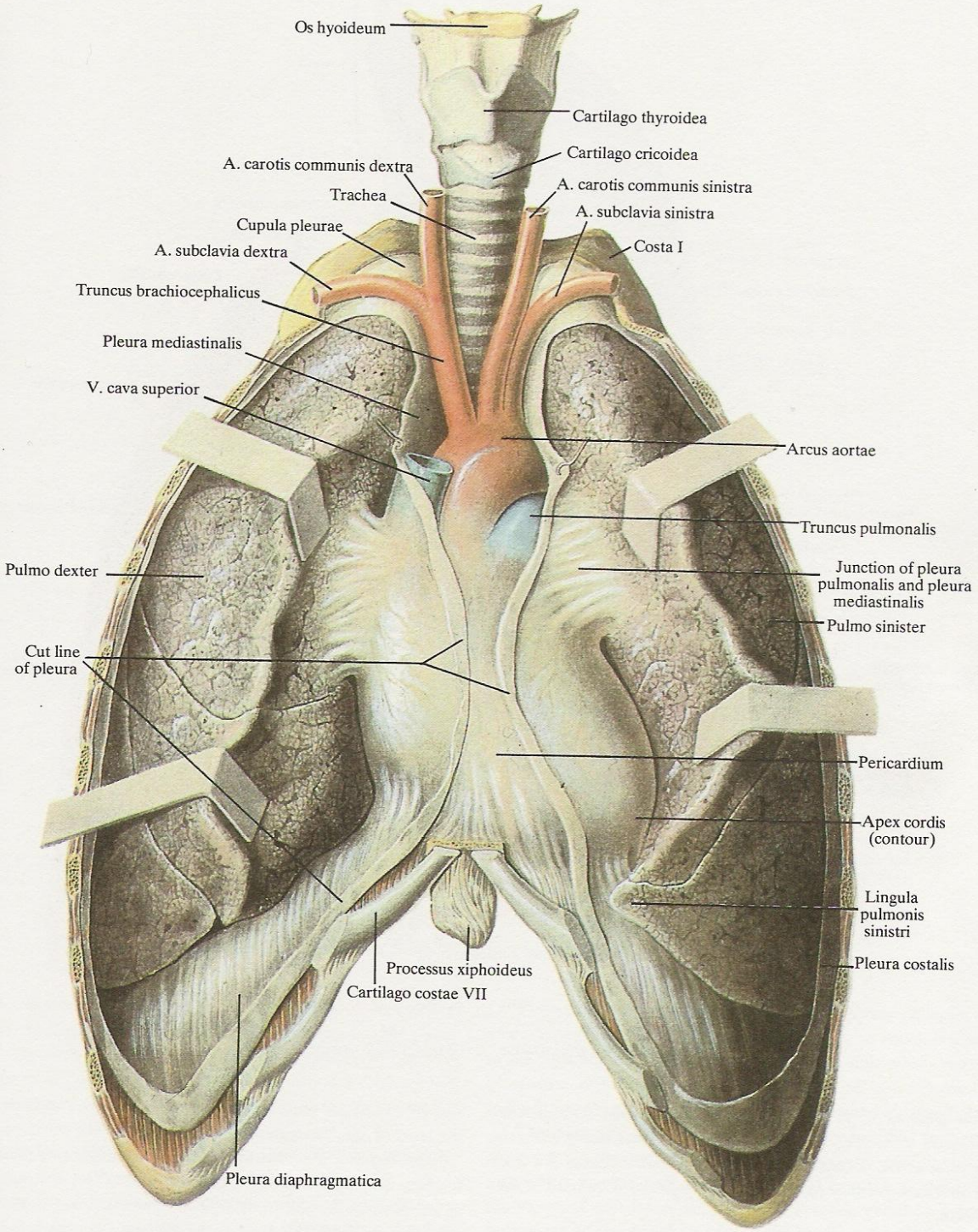
THE LUNGS

The **lung** *(pulmo)* (Figs 521–525) is a paired organ which is surrounded by the right and left pleural sacs. It occupies the greater part of the cavity of the thorax. The regions of the cavity of the thorax containing the right and left lungs and surrounded by the cavities of the pleura are known as the **pleuropulmonary regions** *(regiones pleuropulmonales)*. The parietal pleura is fused with the **endothoracic fascia** *(fascia endothoracica)* whose part at the level of the costal pleura is the **suprapleural membrane** *(membrana suprapleuralis)*, while the part at the level of the diaphragmatic pleura is called the **phrenicopleural fascia** *(fascia phrenicopleuralis)*.



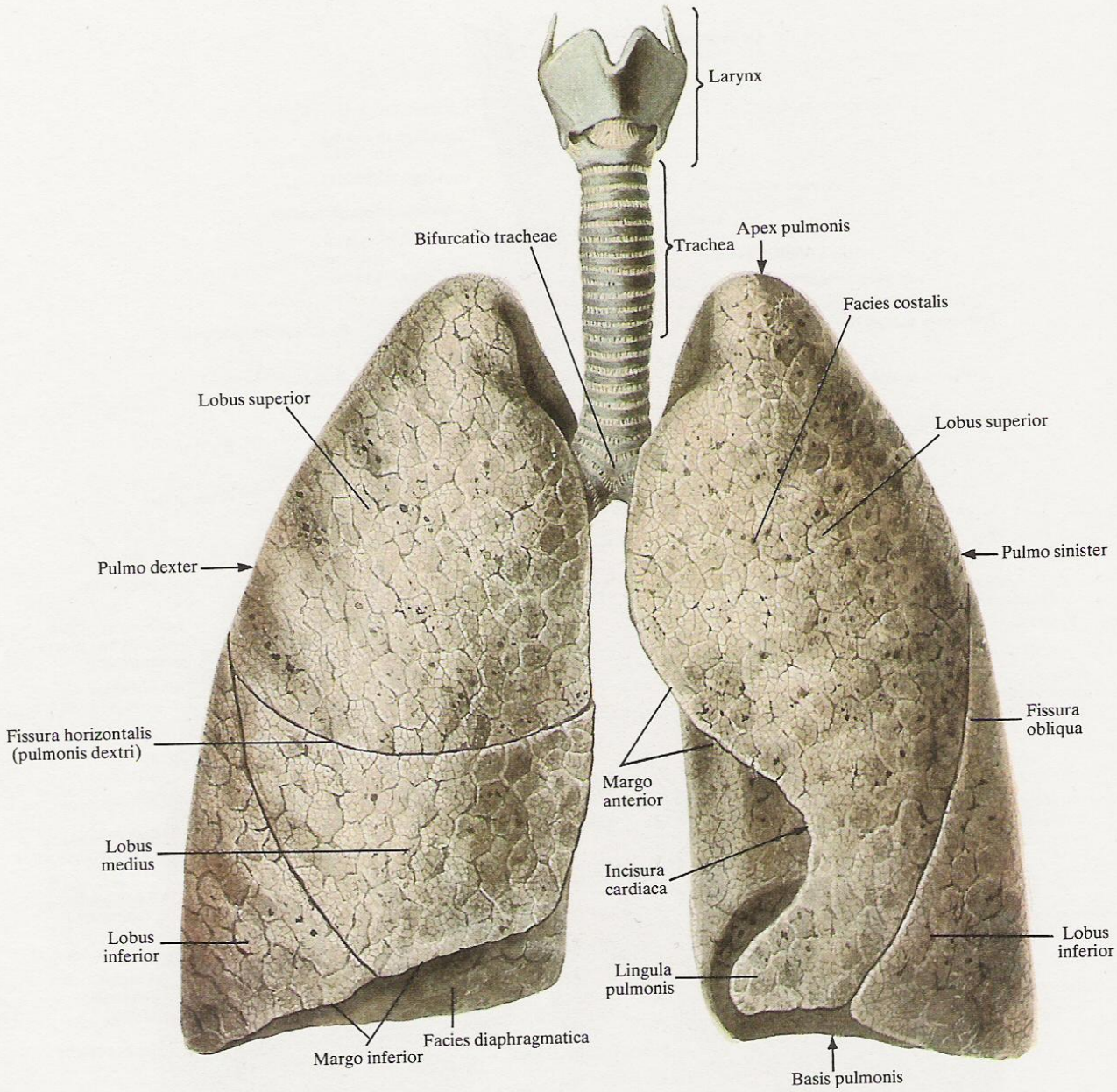
521. *Lungs (pulmones);* anterior aspect (2/5).

(The anterolateral parts of the thoracic wall are removed.)



522. *Lungs (pulmones);* anterior aspect (⅖).

(The anterior borders of the lungs are pulled aside; the medial surface is visible.)



523. *Lungs (pulmones);* anterior aspect (2/5).

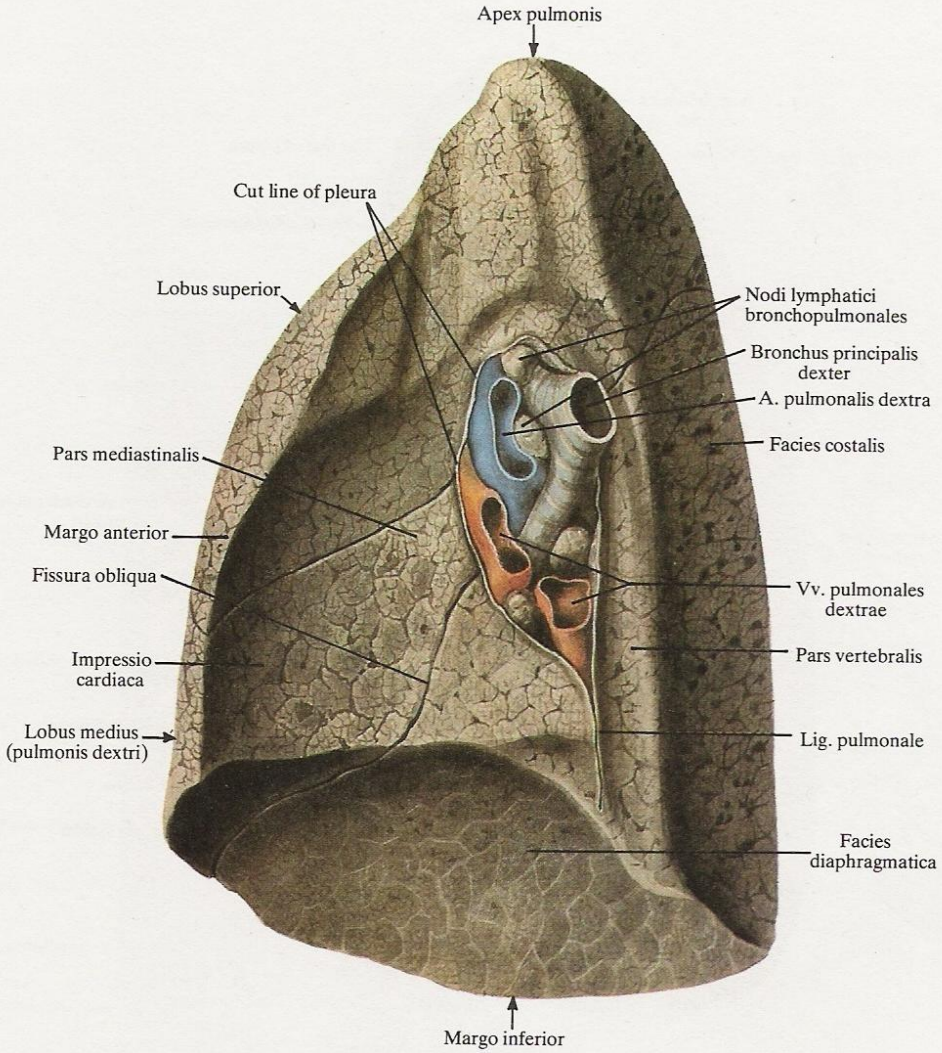
The space between the two pleural sacs which is bounded by the sternum anteriorly, the vertebral column posteriorly, the central tendon of the diaphragm inferiorly, and which faces the inlet of the thorax superiorly *(apertura thoracis superior)* is called the **mediastinum.**

The mediastinum is conventionally classified into the superior and inferior mediastina.

The **superior mediastinum** *(mediastinum superius)* is bounded by the manubrium sterni anteriorly, the vertebral column posteriorly and by the upper parts of the mediastinal pleura on each side to the level of the bifurcation of the trachea.

The superior mediastinum contains the lower two-thirds of the trachea, the upper half of the thoracic part of the oesophagus, part of the thymus (in children) or the tissue replacing it, the arch of the aorta, both brachiocephalic trunks and the greater part of the superior vena cava, the upper part of the thoracic lymphatic duct, lymph glands, and part of the vagus and phrenic nerves.

The **inferior mediastinum** *(mediastinum inferius)* begins below



524. *Right lung (pulmo dexter)* (½).

[Medial surface *(facies medialis)*. Hilum of the lung *(hilus pulmonis)*.]

the horizontal plane drawn through the bifurcation of the trachea. Its anterior wall is formed by the body of the sternum, the posterior wall—by the vertebral column, the inferior wall—by the central tendon of the diaphragm, and the sides are formed by the mediastinal pleura of the lungs below the origin of the right and left bronchi from the trachea.

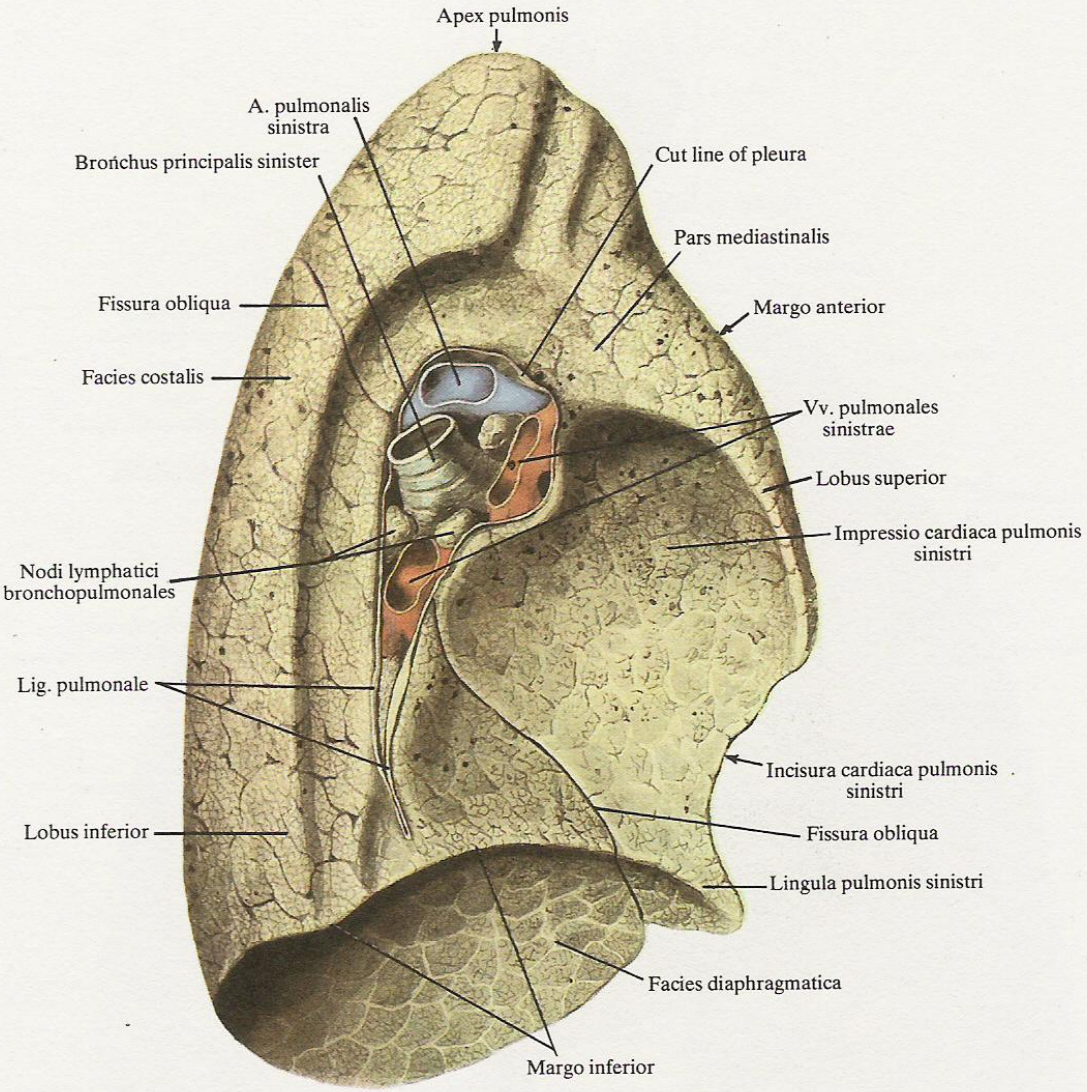
The inferior mediastinum is in turn separated into the anterior, middle, and posterior mediastina.

The **anterior mediastinum** *(mediastinum anterius)* is situated between the sternum and the anterior surface of the pericardium. It is a narrow fissure whose shape resembles an isosceles triangle with its base directed downwards. It contains solitary prepericardial lymph glands and branches of the internal mammary arteries.

The **middle mediastinum** *(mediastinum medium)* occupies most of the inferior mediastinum. It contains the heart which is invested in the pericardium, the pulmonary trunk, the pulmonary veins, the bifurcation of the trachea with the right and left bronchi, the lower half of the phrenic nerve, and the lateral pericardial lymph glands.

The **posterior mediastinum** *(mediastinum posterius)* is bounded anteriorly by the pericardium and posterior surface of the bifurcation of the trachea and the right and left bronchi, posteriorly by the vertebral column (fifth to twelfth thoracic vertebrae), and on both sides by the vertebral part of the mediastinal pleura.

The posterior mediastinum contains the lower half of the thoracic part of the oesophagus, the thoracic aorta, the inferior vena cava, the vena azygos and the inferior vena hemiazygos, the lower



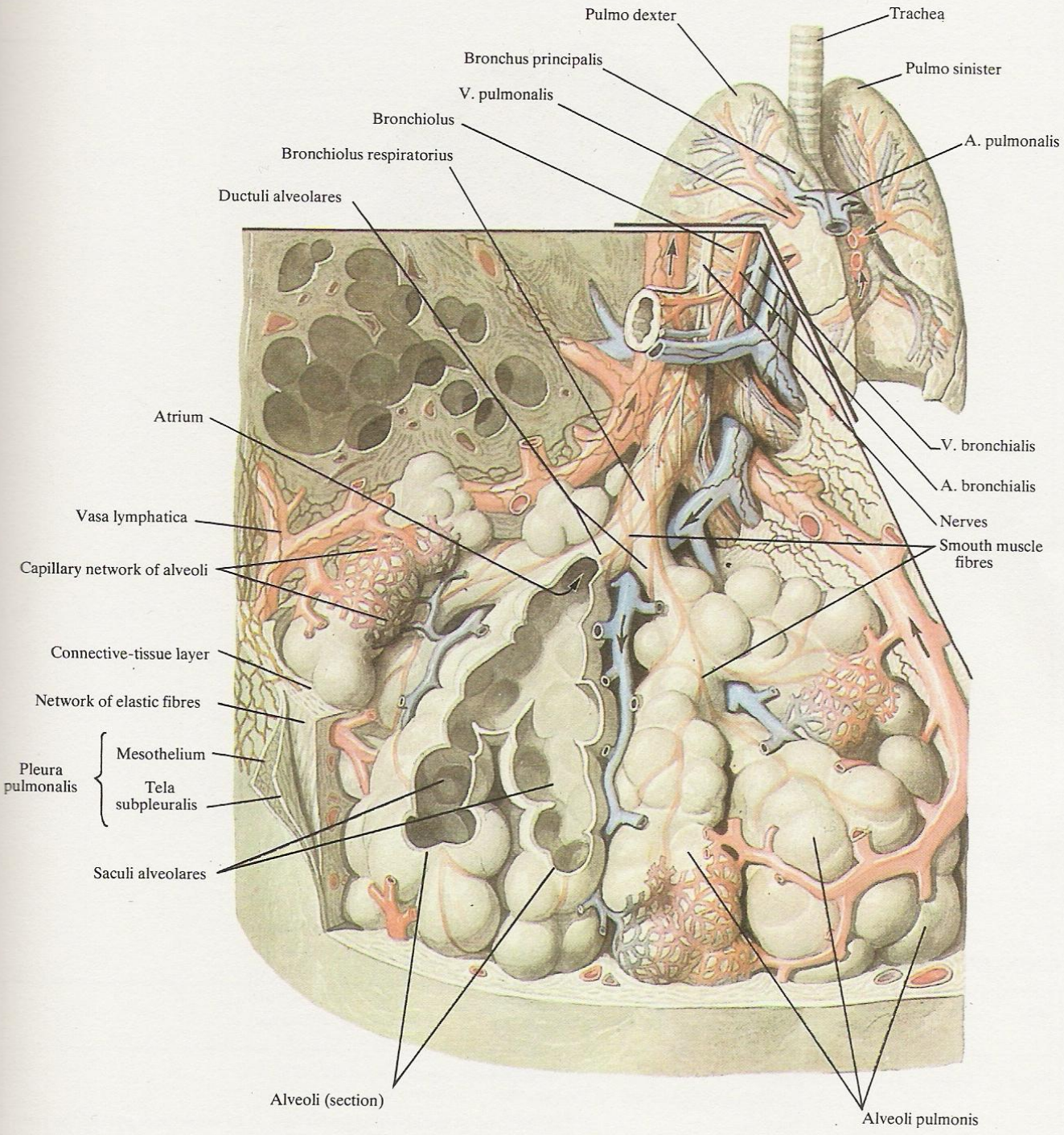
525. *Left lung (pulmo sinister)* (½).

[Medial surface *(facies medialis)*. Hilum of the lung *(hilus pulmonis)*.]

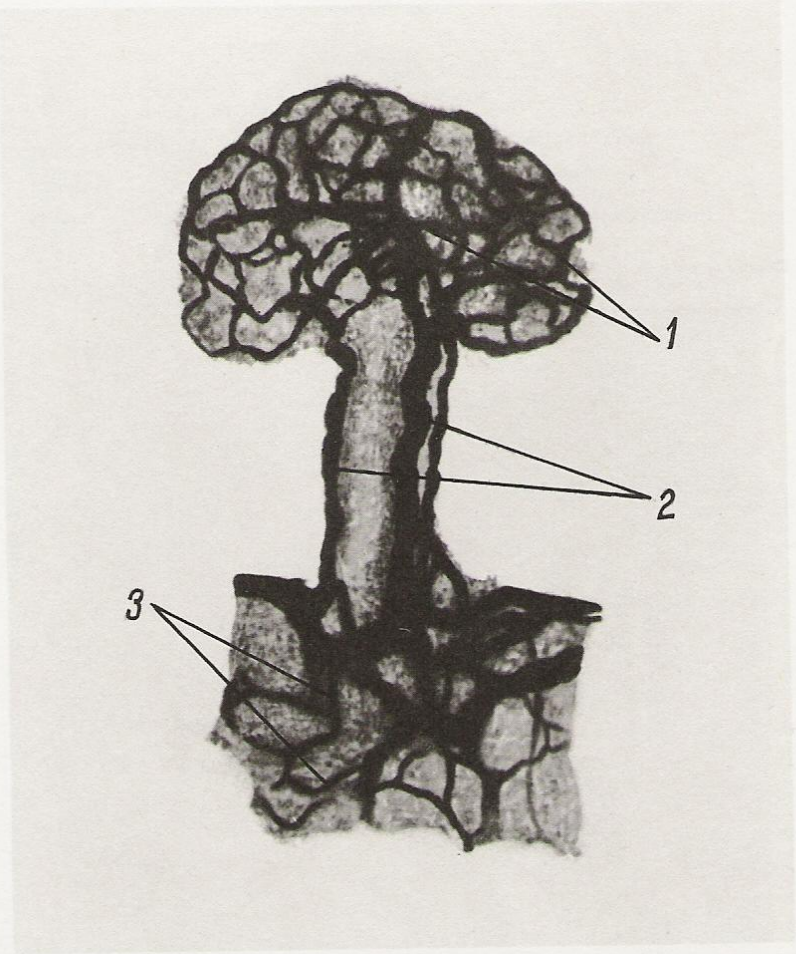
part of the thoracic duct, the vagus nerves, and lymph glands (intercostal, posterior mediastinal, superior phrenic, prevertebral, inferior tracheobronchial, etc.).

The right and left lungs have the shape of a truncated cone; the **apex of the lung** *(apex pulmonis)* is directed upwards into the supraclavicular fossa; the **base of the lung** *(basis pulmonis)* rests on the diaphragm. The right lung is wider but slightly shorter than the left lung. The left lung bears in the lower part of its anterior border a **cardiac notch of the left lung** *(incisura cardiaca pulmonis sinistri)* (Figs 523, 525) into which the heart is fitted.

The lung consists of **lobes** *(lobi)*; the right lung has three and the left has two lobes. In accordance with this, the left lung has a single deep **oblique fissure** *(fissura obliqua)* which divides it into the **upper** and **lower lobes** (*lobus superior* et *lobus inferior*). The right lung has two interlobar fissures; the upper one is called the **horizontal fissure of the right lung** *(fissura horizontalis pulmonis dextri)*. These fissures divide the lung into three lobes, **upper, middle,** and **lower** (*lobus superior, lobus medius* et *lobus inferior*). The fissure between the lobes of the left lung is projected onto the thoracic cage as a line connecting the spinous process of the third thoracic vertebra with the anterior end of the bony part of the sixth rib (Figs 530, 532, 533). The fissures of the right lung are projected on the thoracic cage as follows: the horizontal fissure, which is the boundary between the upper and middle lobes, corresponds to the position of the fourth rib from the axillary line *(linea axillaris)* to the sternum. The lower fissure marks the boundary between the



526. *Acinus of lung* (represented schematically).



527. *Blood vessels of isolated gland of mucous coat of bronchus* (specimen prepared by S. Stebelsky). (Photograph, × 80.)

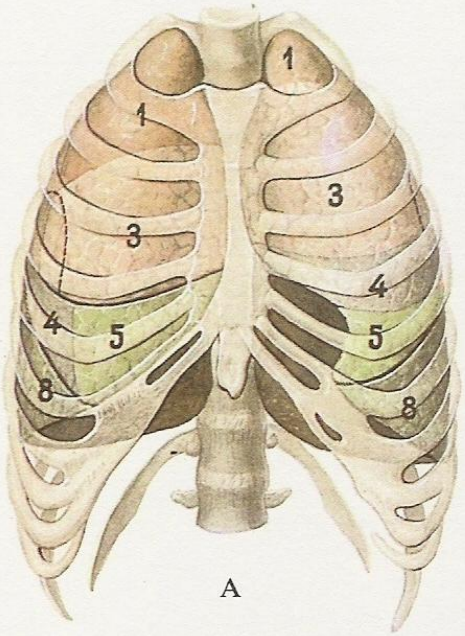
(The vessels are filled with Indian ink; the gland is stained with methylene blue.)

1—capillary network of terminal part of gland
2—capillaries of duct
3—capillary network of mucous coat.

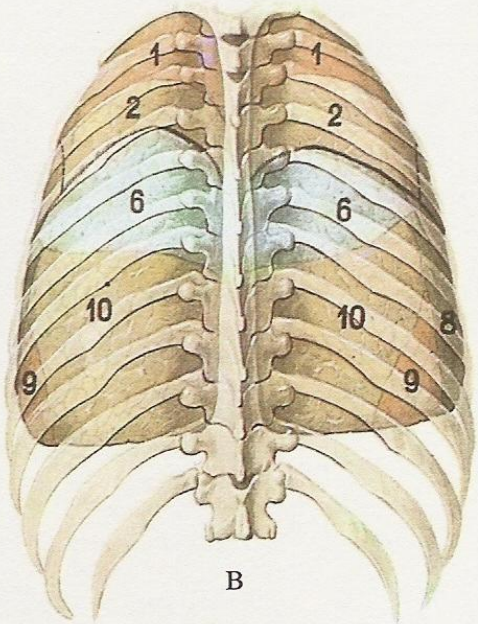
BRONCHOPULMONARY SEGMENTS *(Segmenta bronchopulmonalia)*

Lung	*Lobe*	*No. of segment*	*Name of segment*	*Position of segment*	*Note*
Right	Upper	1	Apical *(segmentum apicale)*	Occupies the superomedial area of the lobe	
		2	Posterior *(segmentum posterius)*	Borders upon the apical segment and is inferior and lateral to it	In some cases part of the posterior or anterior segment forms an independent axillary segment *(segmentum axillare)* corresponding to the axillary fossa

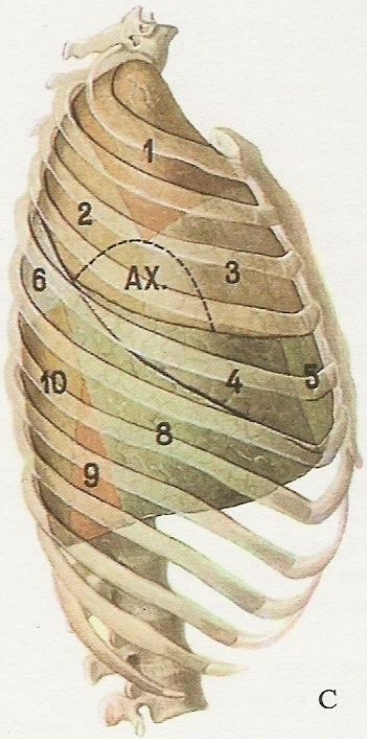
Lung	*Lobe*	*No. of segment*	*Name of segment*	*Position of segment*	*Note*
		3	Anterior *(segmentum anterius)*	Comprises part of the ventral surface of the upper lobe, and is situated in front and downwards of the apex of the lobe	
	Middle	4	Lateral *(segmentum laterale)*	Comprises the dorsolateral and medial-inferolateral parts of the lobe	
		5	Medial *(segmentum mediale)*	Comprises the anteromedial and superolateral parts of the lobe	
	Lower	6	Apical *(segmentum apicale)*	Situated in the paravertebral region of the lobe, occupying its wedge-shaped apex	
		7	Medial basal (*segmentum basale mediale* s. *cardiacum*)	Situated in the inferomedial part of the lobe and forms part of its dorsal and medial surfaces	
		8	Anterior basal *(segmentum basale anterius)*	Makes up the anterolateral part of the lobe, forming part of its inferior and lateral surfaces	
		9	Lateral basal *(segmentum basale laterale)*	Comprises the mediolateral part of the lobe, partly contributing to the formation of its inferior and lateral surfaces	
		10	Posterior basal *(segmentum basale posterius)*	Comprises the posteromedial part of the lobe, forming its posterior and medial surfaces	
Left	Upper	1	Apical *(segmentum apicale)*	Comprises the superomedial part of the lobe, forming part of its posterior and anterior surfaces	
		2	Posterior *(segmentum posterius)*	Situated downwards and to the back of the apical segment	
		3	Anterior *(segmentum anterius)*	Occupies part of the costal and mediastinal surfaces of the lobe on the level of the first to fourth ribs	
		4	Superior lingular *(segmentum lingulare superius)*	Constitutes the middle part of the upper lobe, contributes to the formation of all its surfaces	The superior and inferior lingular segments comprise the lingula pulmonis *(lingula pulmonis sinistri)*
		5	Inferior lingular *(segmentum lingulare inferius)*	Comprises the lower part of the upper lobe	
	Lower	6	Apical *(segmentum apicale)*	Occupies the wedge-shaped apex of the lobe in the paravertebral region	
		7	Medial basal (*segmentum basale mediale* s. *cardiacum*)	Occupies a median position and contributes to the formation of the mediastinal surface of the lobe	
		8	Anterior basal *(segmentum basale anterius)*	Occupies the anterolateral part of the lobe, partly forming its inferior and lateral surfaces	
		9	Lateral basal *(segmentum basale laterale)*	Occupies the mediolateral part of the lobe and contributes to the formation of its inferior and lateral surfaces	
		10	Posterior basal *(segmentum basale posterius)*	Occupies the posteromedial part of the lobe and forms its posterior and medial surfaces	



A



B



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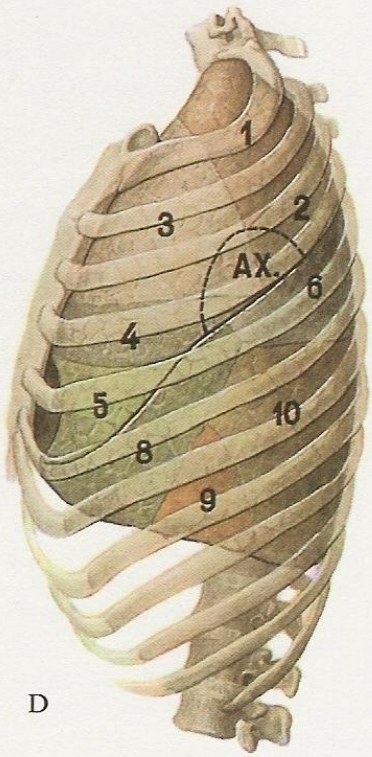

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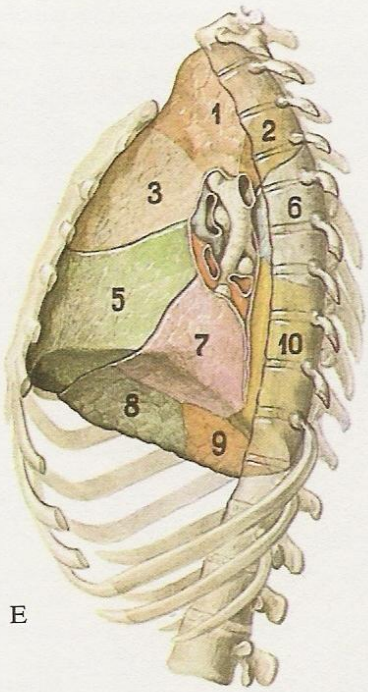

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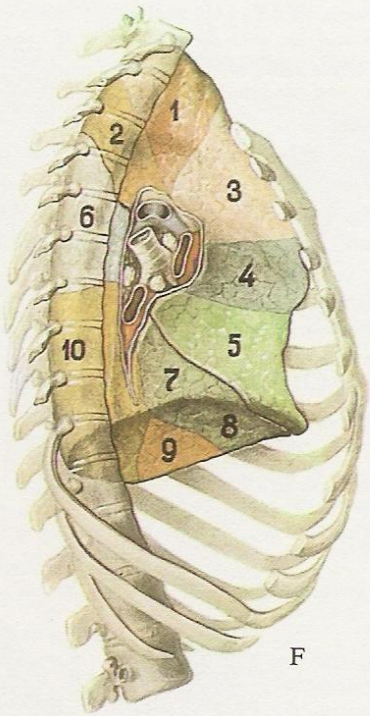
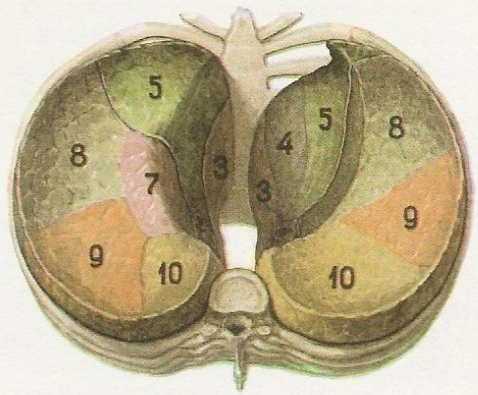


F

528, 529. *Bronchopulmonary segments (segmenta bronchopulmonalia)* (represented schematically).

A—anterior aspect; B—posterior aspect; C—lateral aspect, right side; D—lateral aspect, left side; E—medial aspect, right side; F—medial aspect, left side; G—inferior aspect.

Right lung, upper lobe:
1—apical segment *(segmentum apicale)*
2—posterior segment *(segmentum posterius)*
3—anterior segment *(segmentum anterius)*
middle lobe:
4—lateral segment *(segmentum laterale)*
5—medial segment *(segmentum mediale)*
lower lobe:
6—apical segment *(segmentum apicale)*
7—medial basal segment *(segmentum basale mediale* s. *cardiacum)*
8—anterior basal segment *(segmentum basale anterius)*
9—lateral basal segment *(segmentum basale laterale)*
10—posterior basal segment *(segmentum basale posterius)*
Left lung, upper lobe:
1—apical segment *(segmentum apicale)*
2—posterior segment *(segmentum posterius)*
3—anterior segment *(segmentum anterius)*
4—superior lingular segment *(segmentum lingulare superius)*
5—inferior lingular segment *(segmentum lingulare inferius)*
lower lobe:
6—apical segment *(ssegmentum apicale)*
7—medial basal segment *(segmentum basale mediale* s. *cardiacum)*
8—anterior basal segment *(segmentum basale anterius)*
9—lateral basal segment *(segmentum basale laterale)*
10—posterior basal segment *(segmentum basale posterius)*



G

middle and lower lobes in front and between the upper and lower lobes behind and passes on a line connecting the spinous process of the third thoracic vertebra with the cartilage of the sixth rib on the mamillary line (*linea mamillaris* s. *medioclavicularis*) (Figs 531, 532).

The following surfaces are distinguished in the lungs: the **costal surface** *(facies costalis)*, **diaphragmatic surface** *(facies diaphragmatica)*, **interlobar surfaces** *(facies interlobares)*, and **medial surface** *(facies medialis)* which has a vertebral part *(pars vertebralis)*, **mediastinal part** *(pars mediastinalis)*, and a **cardiac impression** *(impressio cardiaca)*.

The costal surface of the lungs is convex and often bears impressions of the ribs (Fig. 523). The concave mediastinal surface has a bay-like depression called the **hilum of the lung** *(hilus pulmonis)* (Figs 524, 525) through which the pulmonary and bronchial arteries, the bronchus, and nerves enter the lung and the pulmonary and bronchial veins and lymph vessels leave it. The relationship of these structures in the hilum of the right lung differs from that in the left lung. In the hilum of the right lung the bronchus occupies an anterosuperior position, the veins—a posteroinferior position, and the artery is between them. In the hilum of the left lung the artery takes an anterosuperior position, the veins—a posteroinferior position, and the bronchus—a middle position.

The whole complex of these structures (vessels, lymph glands, nerves, and bronchi) filling the hilum comprises the **root of the lung** *(radix pulmonis)* (Figs 524, 525).

The junctions of the surfaces of the lungs are called borders.

The lung has two borders: (1) the **inferior border** *(margo inferior)* and the **anterior border** *(margo anterior)*.

The anterior border of the left lung bears a **cardiac notch** *(incisura cardiaca)* in its lower part.

The lung is pale pink in a child but acquires the colour of slate and bands and spots with age. Normally the tissue of the lung is elastic and microporous on section.

The parenchyma of the lung is made up of a system of branching airways (the bronchi, their branches, bronchioles, alveoli) and branching blood vessels (arteries and veins), lymph vessels, and nerves. All these structures are connected to one another by connective tissue (Fig. 526).

THE BRONCHOPULMONARY SEGMENTS

The lung is subdivided into **bronchopulmonary segments** *(segmenta bronchopulmonalia)* (Figs 528, 529).

A bronchopulmonary segment is an area of a lobe of the lung which is ventilated by a tertiary bronchus and supplied with blood by one artery (the veins pass in the intersegmental spaces and are, as a rule, common to two neighbouring segments). The segments are separated from one another by connective-tissue septa and have the shape of irregular cones and pyramids whose apex is directed to the hilum and the base—to the surface of the lung. According to the International Nomenclature, the right and left lungs are divided into ten segments. A bronchopulmonary segment is not simply a morphological but a functional unit of the lung because many pathological processes in the lungs arise within the boundaries of one segment.

The tables and figures presented above show the position of each segment (pp. 154–155, Figs 528, 529).

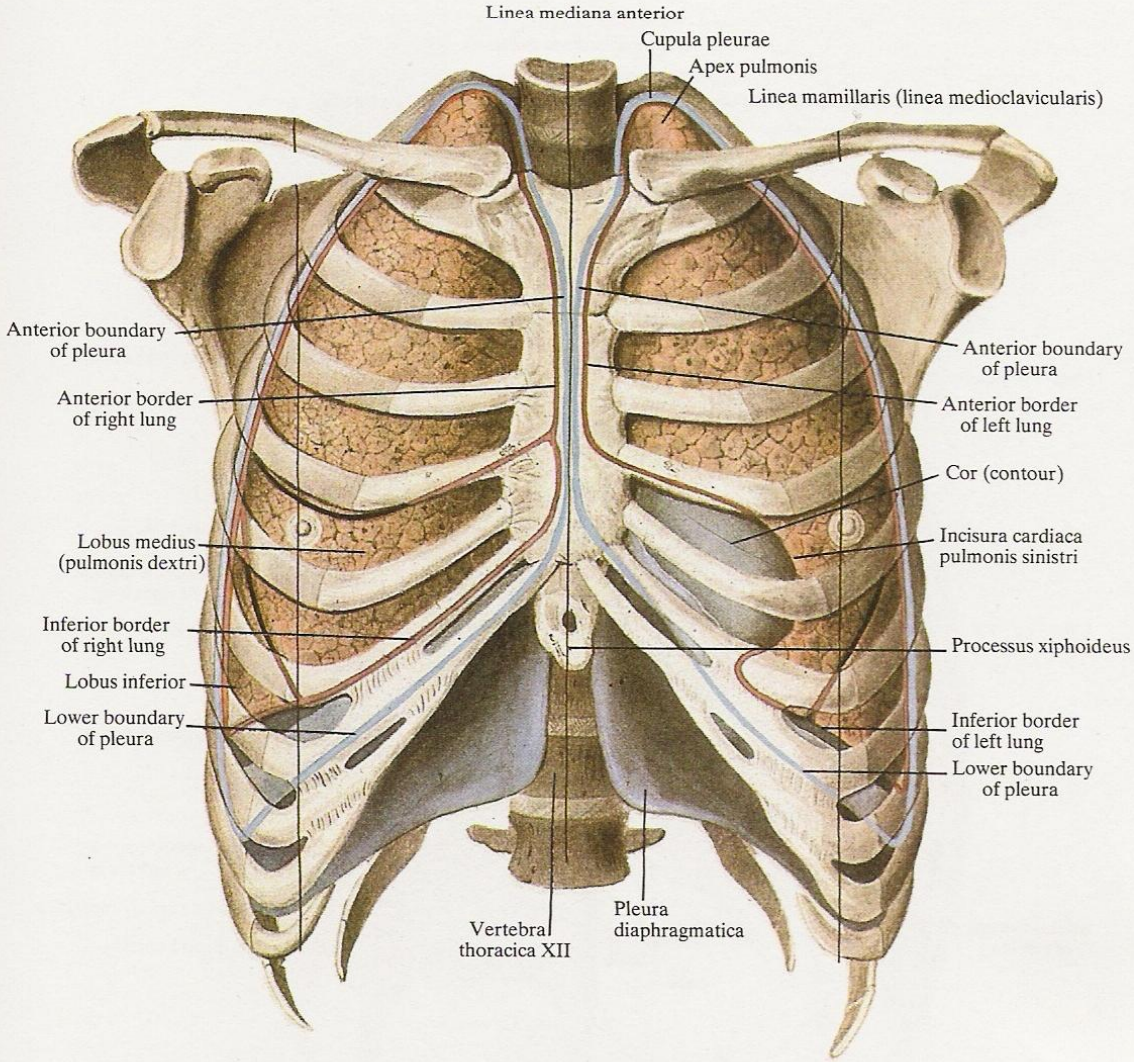
THE BOUNDARIES OF THE LUNGS

The apex of the lung protrudes 2–3 cm above the level of the clavicle in the supraclavicular fossa, medial to the scalenus muscles.

The anterior boundaries of both lungs behind the sternum form the figure of an hourglass. Their edges come closer together in the region of the second to fourth ribs. A narrow vertical space forms here between the lungs, usually slightly to the left of the midline.

Above the second rib the boundaries of the right and left lungs diverge to form a wider space which is occupied by the thymus in children and by its remnants in adults. Below the fourth rib the boundaries also diverge, mainly due to the anterior border of the left lung (incisura cardiaca). An area of the anterior surface of the heart comes in contact with the thoracic wall here.

Posteriorly the borders of the right and left lung are separated for a distance equal to the width of the vertebral bodies. The



530. *Boundaries of lobes of lungs and pleura*; anterior aspect (represented semischematically) (⅓).

(Projection of boundaries on the skeleton of the thorax. The pleura is coloured blue. The red line outlines the boundaries of the lobes of the lungs, the blue line—the boundaries of the pleura.)

boundaries of the apices and anterior borders of the lungs coincide with the boundaries of the pleura in these parts (see *The Pleura*).

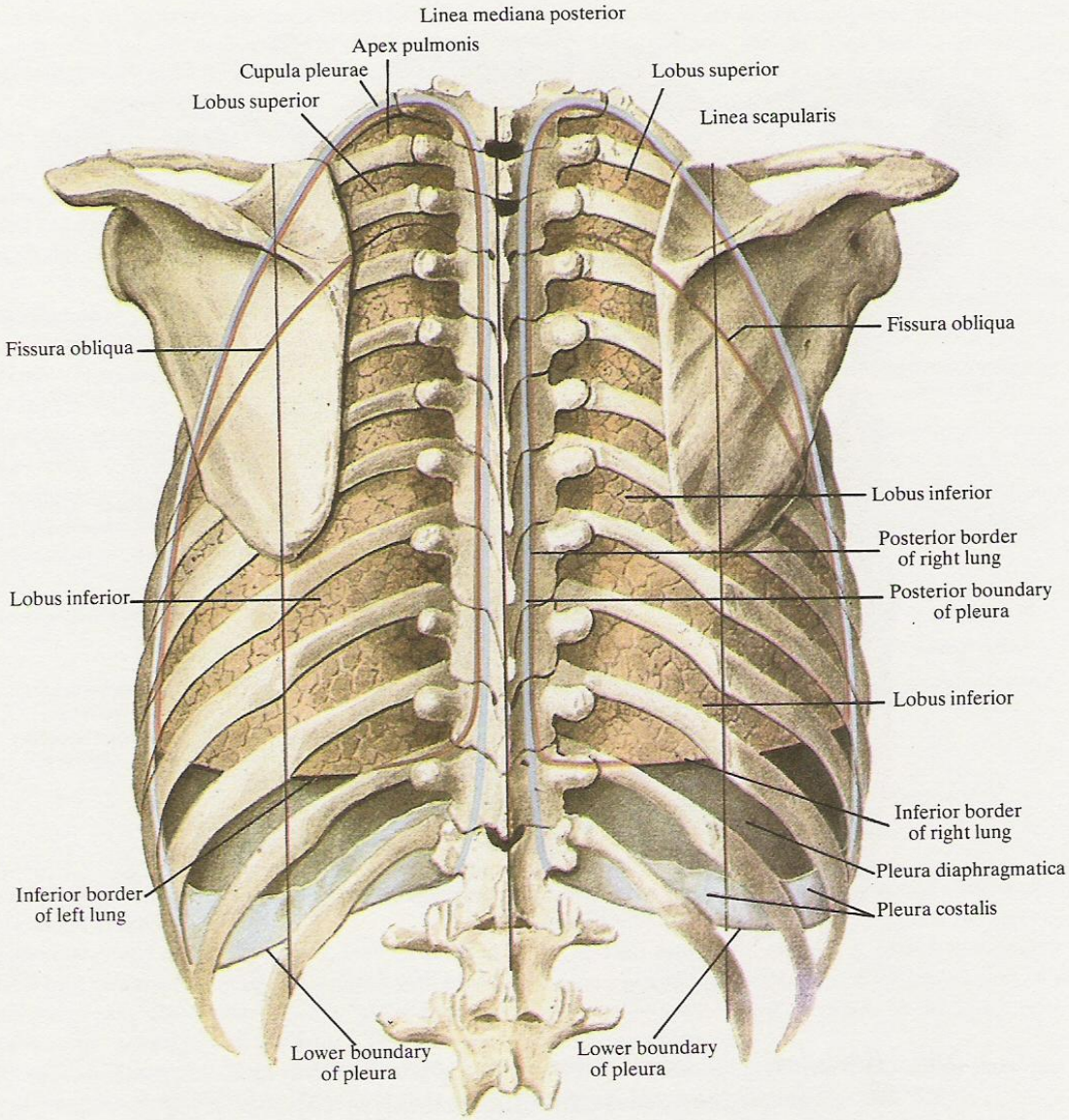
The lower boundary of the right lung (Figs 530–532) is determined:

on the mamillary line (*linea mamillaris* s. *medioclavicularis*)	–	on the sixth rib (inferior border);
on the axillary line *(linea axillaris)*	–	on the eighth rib;
on the scapular line *(linea scapularis)*	–	on the tenth rib;
on the posterior median line *(linea mediana posterior)*	–	on the level of the spinous process of the eleventh thoracic vertebra.

The lower boundary of the left lung (Figs 530, 531, 533) passes in front on the level of the fourth rib horizontally and then descends on the mamillary line to the sixth rib; beginning from this level the boundaries of the right and left lungs are projected in an almost similar manner.

Innervation: the anterior and posterior pulmonary plexus (*plexus pulmonales anterior* et *posterior*).

Blood supply: the bronchial arteries *(arteriae bronchiales)*.



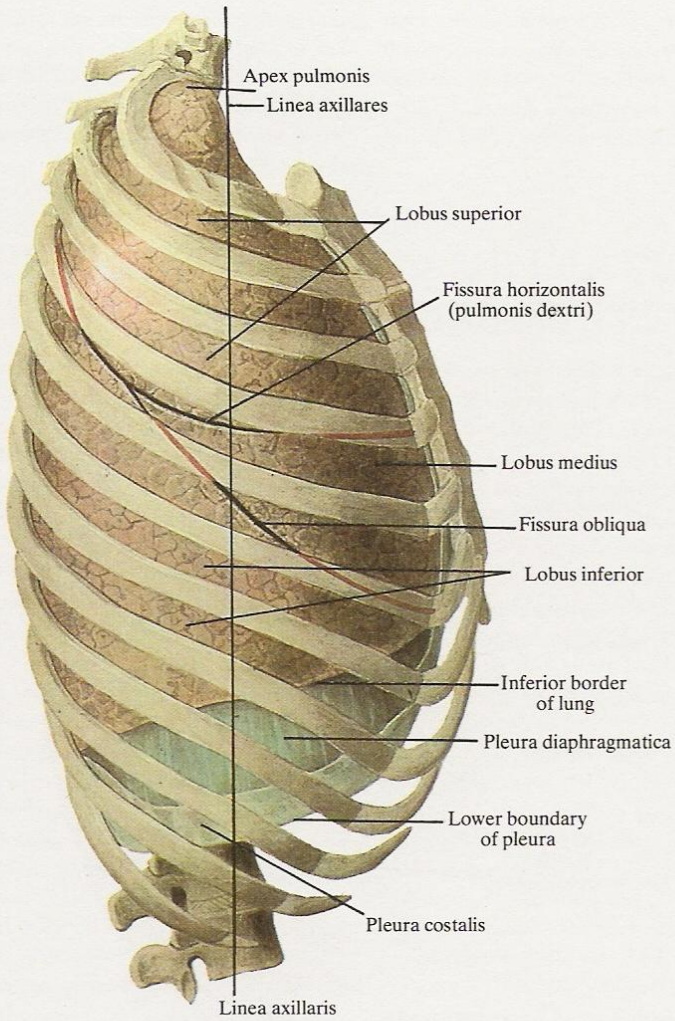
531. *Boundaries of lobes of lungs and pleura;* posterior aspect (represented semischematically) (⅓).

THE PLEURA

The lungs are covered by the **pleura** (see Figs 521, 522) which, like the peritoneum, is a smooth glistening **serous membrane** *(tunica serosa)*. The **parietal pleura** *(pleura parietalis)* and **visceral,** or **pulmonary pleura** (*pleura visceralis* s. *pulmonalis*) are distinguished. Between them is the **cavity of the pleura** *(cavum pleurae)* filled with a small amount of **pleural fluid** *(liquor pleurale)*.

The pulmonary pleura covers the parenchyma of the lung directly and, being closely fused with it, penetrates deeply into the interlobular fissures.

The parietal pleura is fused with the walls of the cavity of the thorax and forms the **costal pleura** *(pleura costalis)* and the **diaphragmatic pleura** *(pleura diaphragmatica)* as well as the **mediasti-**



532. *Boundaries of lobes of right lung and pleura;* lateral aspect (represented semischematically) (⅓).

nal pleura *(pleura mediastinalis)* by which the mediastinum is bounded on either side (Figs 521, 522). In the region of the hilum of the lungs the parietal pleura is continuous with the pulmonary pleura and its reflection covers the root of the lung in front and behind.

Below the root of the lung the fold of the pleura forms a duplicature which is called the **pulmonary ligament** *(ligamentum pulmonale)*.

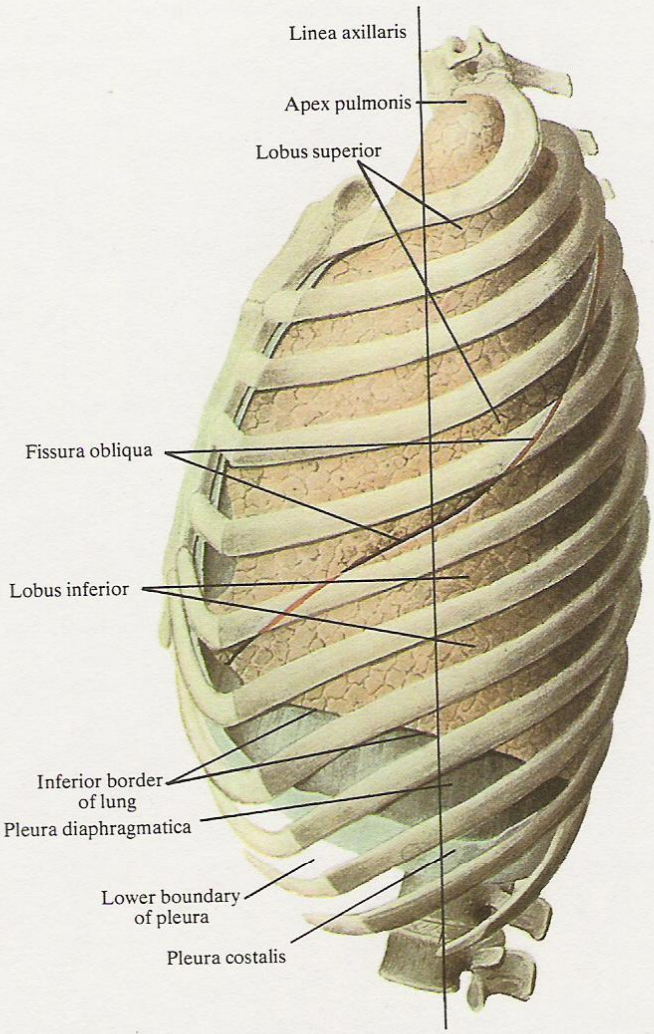
In the region of the apex of the lung the parietal pleura forms the **cervical pleura** *(cupula pleurae)* whose upper parts adjoin the head of the first rib dorsally, while the anterolateral surface is related to the scalenus muscles.

The wedge-shaped parts of the cavity of the pleura between the two parietal pleurae are called the **recesses of the pleura** (*sinus* s. *recessus pleurales*) (Fig. 521).

The following recesses are distinguished:

1. The **costodiaphragmatic recess** (*sinus* s. *recessus costodiaphragmaticus*) is at the junction of the costal pleura with the diaphragmatic pleura.

2. The **costomediastinal recesses** (*sinus* s. *recessus costomediastinales*) form where the costal pleura is continuous with the mediastinal pleura; the anterior recess is behind the sternum; the posterior recess, which is less distinctly pronounced, is in front of the vertebral column.



533. *Boundaries of lobes of right lung and pleura;* lateral aspect (represented semischematically) (⅓).

The lower boundaries of the lungs do not coincide with the boundaries of the parietal pleura (Figs 530–533).

The lower boundary of the parietal pleura is outlined as follows:

on the anterior median line *(linea mediana anterior)* – on the sixth or seventh rib;
on the mamillary line *(linea medioclavicularis)* – on the seventh rib (inferior border);
on the axillary line *(linea axillaris)* – on the tenth rib;
on the scapular line *(linea scapularis)* – on the eleventh or twelfth rib;
on the posterior median line *(linea mediana posterior)* – on the twelfth rib.

The depth of the costodiaphragmatic recess is therefore greatest on the axillary line.

The anterior boundary of the parietal pleura of the right and left lungs passes downwards from the sternoclavicular joints behind the manubrium and body of the sternum to the inferior border of the sternal ends of the fourth ribs. From this point the anterior margin of the pleura of the right lung continues downwards to

the intersection of the sixth rib with the anterior median line; that of the pleura of the left lung turns to the left at the level of the fourth rib, describes the arch of the cardiac notch, and descends to the intersection of the seventh rib with the mamillary line.

On their way the anterior margins of the parietal pleura of the right and left lungs diverge in the upper and lower parts to form the thymus triangle behind the manubrium sterni and the pericardium triangle in the lower part.

The thyroid, parathyroid and thymus glands are described in Vol. III in the section *The Endocrine Glands*.

DEVELOPMENT AND AGE FEATURES OF THE RESPIRATORY SYSTEM

The respiratory organs developing in the third week of intrauterine life are represented by a small protrusion of the ventral wall of the foregut, which then (the fourth week) divides into two caudally growing pouches called the bronchopulmonary buds. The last-named develop into the bronchi and lungs within two months, while the unpaired primary protrusion gives rise to the larynx and trachea.

The cavity of the nose, the vestibule, and the olfactory region, develop from the olfactory, nasal pits; the remaining part of the cavity arises from the primitive oral cavity after the palatine processes divide it into the cavity proper of the mouth and the cavity of the nose. The cavity of the nose of the newborn (Figs 483 A, 483 B) is very narrow and its floor is slightly below the line drawn through the right and left infra-orbital foramina. The inferior meatus of the nose is undeveloped, the superior meatus is poorly developed, the middle meatus is the largest; all the meatuses develop completely by the age of 14–15 years. The paranasal sinuses are in a germinal state. The air cells of the ethmoid bone form by the age of 2 years; the frontal and sphenoidal sinuses are absent in the newborn, and appear at the end of the first or the beginning of the second year; the maxillary sinus exists but is poorly developed and only by the age of 9 years it develops so that its floor is on the level with the floor of the cavity of the nose.

The larynx of the newborn is funnel-shaped, measures up to 1.53 cm in length, and its sagittal dimension is less than the frontal one. It is situated cranially to that of an adult for a distance of almost three vertebrae, descends gradually with age, and takes the same position as that in an adult by the age of 13–14 years.

The trachea of the newborn is up to 50 mm long and is almost conic in shape. It is situated slightly to the right of the midplane; its cranial end reaches the level of the lower border of the fourth cervical vertebra, while its caudal end terminates by the bifurcation at the level of the third or fourth thoracic vertebra; by the age of 13 years the bifurcation is at the level of the lower border of the sixth thoracic vertebra. The lumen of the trachea varies: in the newborn it is slightly flattened, then takes an elongated form with age, and is rounded in the adult. In the newborn, in whom the cartilages are still incompletely developed, the posterior wall is devoid of cartilages and constitutes a much greater part of the trachea as compared to that of an adult. The right bronchus in a newborn measures 1.17 cm in length and 1.4 cm in circumference; the left bronchus—1.6 cm in length and 1.2 cm in circumference. By the age of 15–16 years the right bronchus is 3.28 cm long and its circumference measures 3.6 cm, while the respective figures for the left bronchus are 3.05 cm and 3.16 cm.

The lungs of a newborn who has made the first breaths are much larger than the lungs of a newborn baby who has not breathed yet. They are more elongated and fill (together with the heart and thymus) the cavity of the thorax completely. Their lower boundary passes on the level with the tenth and eleventh ribs at the back and on the level with the eighth rib on the axillary line; the apices of the lungs are on the level of the first rib but later, with age, they descend gradually like all the other organs of the cavity of the thorax. The proportions of the lobes and lungs as a whole become the same as in adults only at the beginning of the second year of life. Growth of the bronchial and alveolar tree (branching of new generations of bronchi and bronchioles) continues to the age of 7 years.

THE UROGENITAL SYSTEM (THE UROGENITAL APPARATUS)

Systema urogenitale
(Apparatus urogenitalis)

The **urogenital system**, or **apparatus** (*systema urogenitale* s. *apparatus urogenitalis*) (Figs 534, 535) includes two systems of organs: the urinary organs which are responsible for the production of urine and its excretion from the body, and the genital organs which are concerned with the function of reproduction.

The organs of these systems have a common origin, they are in close topographic relationship but differ in function.

THE URINARY ORGANS

The **urinary organs** *(organa uropoëtica)* (Figs 536–546) are part of the general system of excretion and contribute to the maintenance of the constancy of the body's internal environment.

The group of urinary organs includes the **kidneys** *(renes)*, the **ureters** *(ureteres)*, the **urinary bladder** *(vesica urinaria)*, and the **urethra**.

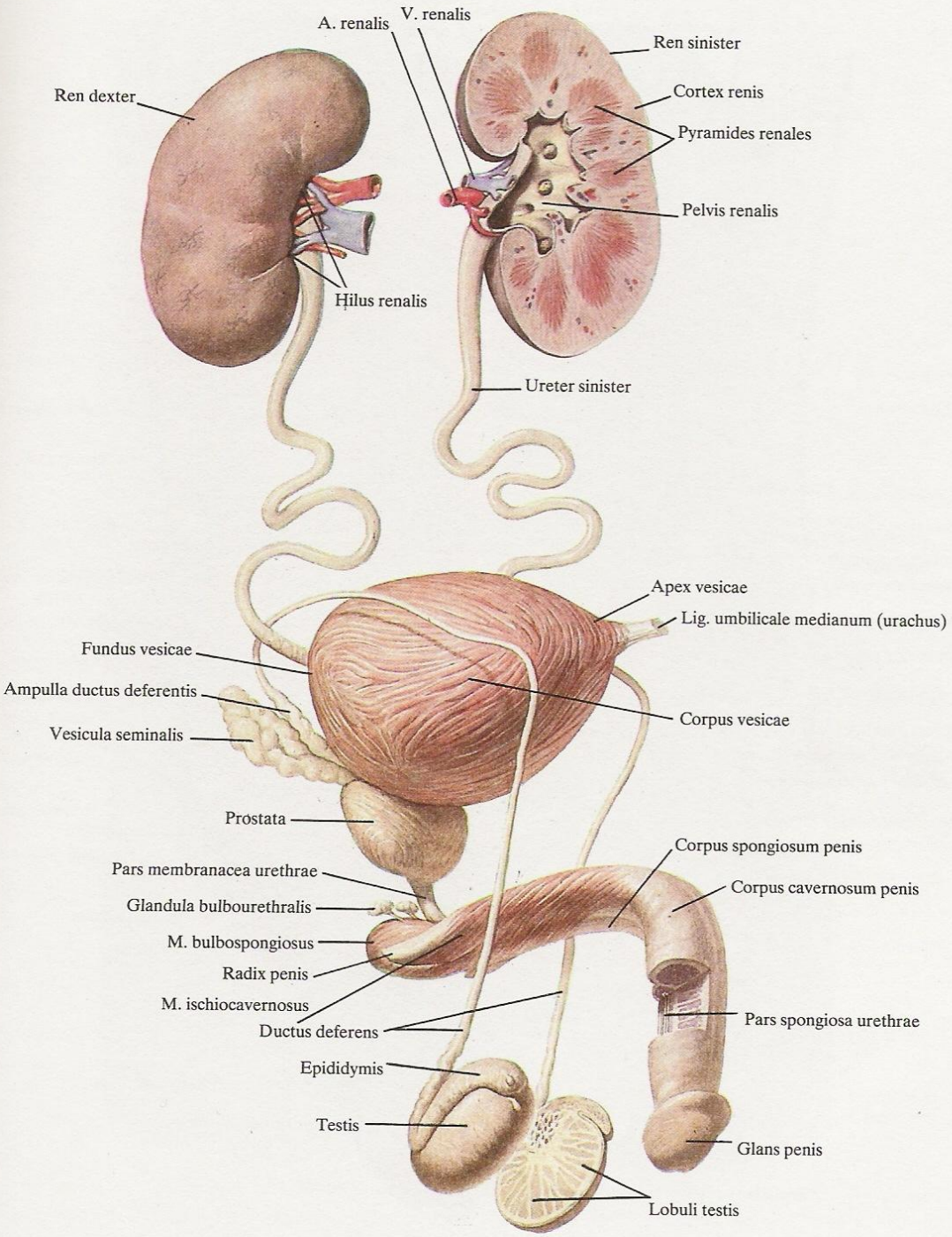
The most important organ of the urinary system, the kidney, is a compound tubular gland which specializes in the removal of excess amount of water and products of tissue metabolism from the blood. The kidneys excrete **urine** *(urina)* which contains urea, uric acid, salts, and other substances whose excessive accumulation in the body disturbs its vital activity.

The urine flows from the kidneys along the system of the urinary tract. Since micturition occurs periodically, the tract includes a reservoir in which the urine is collected, namely the urinary bladder.

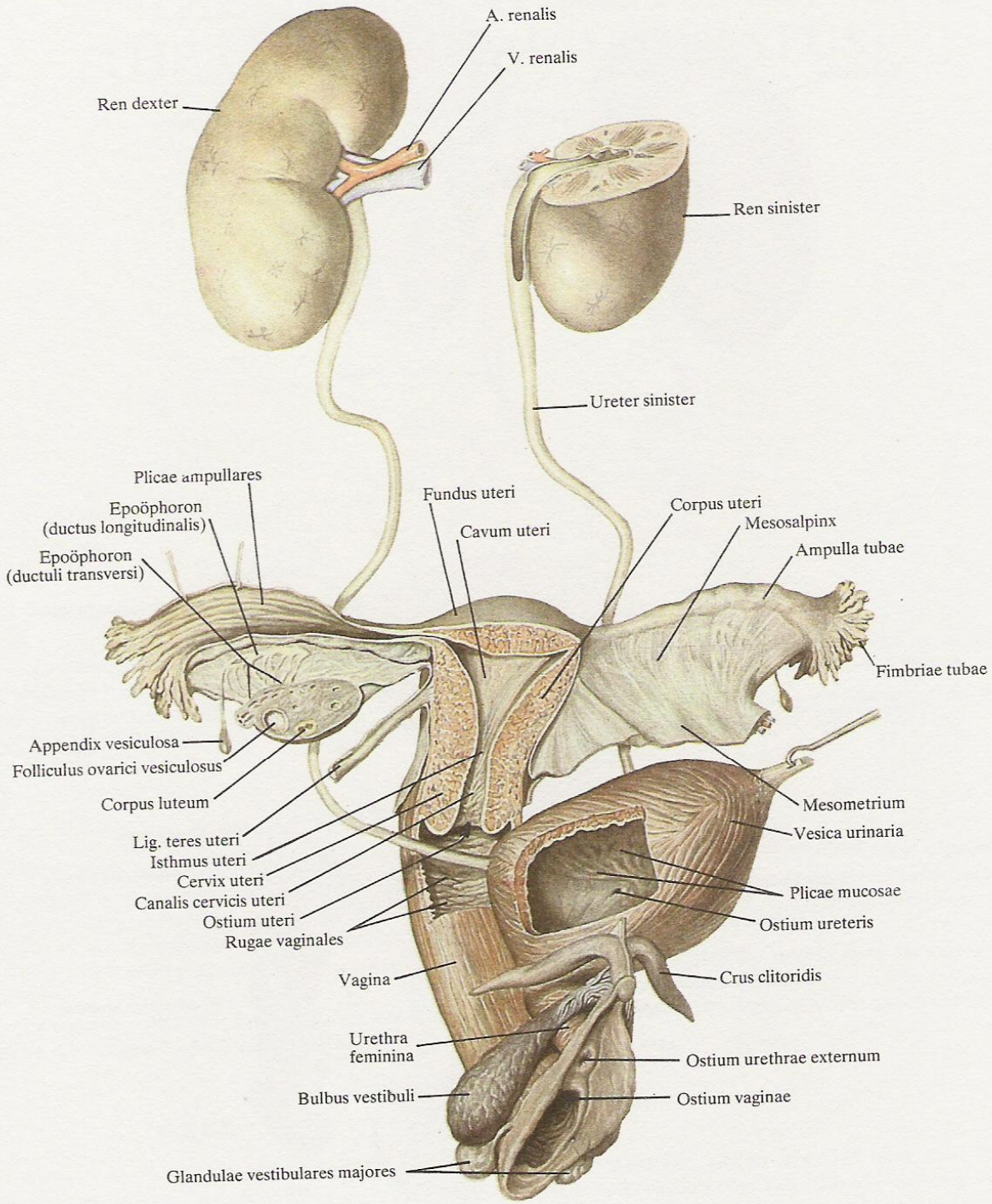
THE KIDNEYS

The **kidney** *(ren)* is a paired bean-shaped organ (Figs 534–546). The kidneys are situated in the cavity of the abdomen in the lumbar region on either side of the vertebral column. Each kidney measures 10–12 cm in length, 5–6 cm in width, and 4 cm in thickness. One kidney weighs 120 to 200 g. The left kidney is slightly longer than the right kidney and sometimes weighs more. The kidneys are usually dark-brown in colour.

Each kidney has an anterior and posterior surfaces, a lateral and medial margins, and an upper and lower ends. The **anterior surface** *(facies anterior)* (Figs 538, 540) is convex and faces slightly laterally. The upper two-thirds of the right kidney are in relation with the liver, while the upper third of the left kidney is related to the stomach. The **posterior surface** *(facies posterior)* (Figs 539, 541) is flat. The lateral portion of each kidney is in contact with the quadratus lumborum muscle. The **lateral margin** *(margo lateralis)* is convex and faces slightly the posterior wall of the abdomen; the

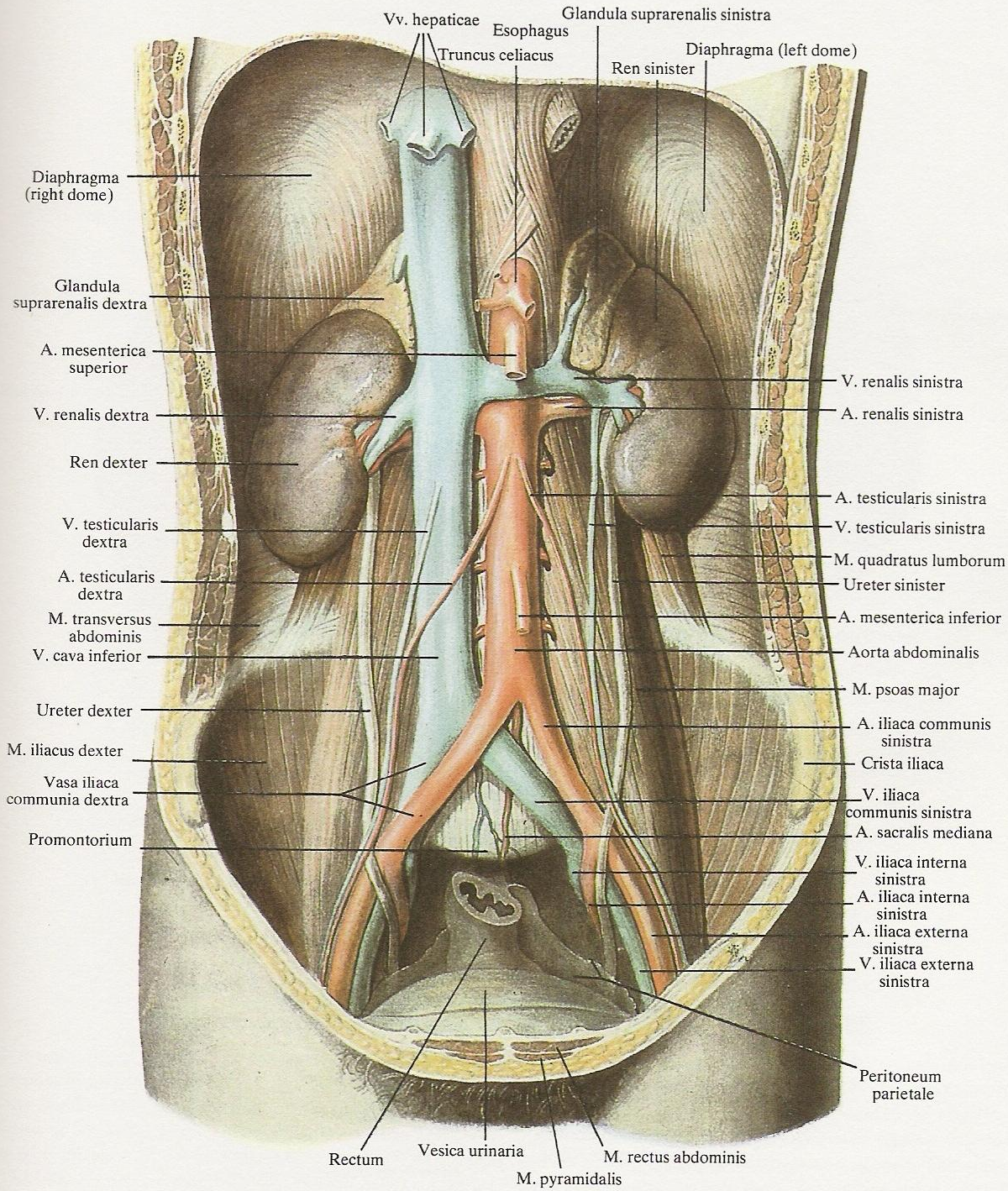


534. *Male urogenital apparatus* (represented semischematically).
(Section of left kidney, testis, and part of penis.)



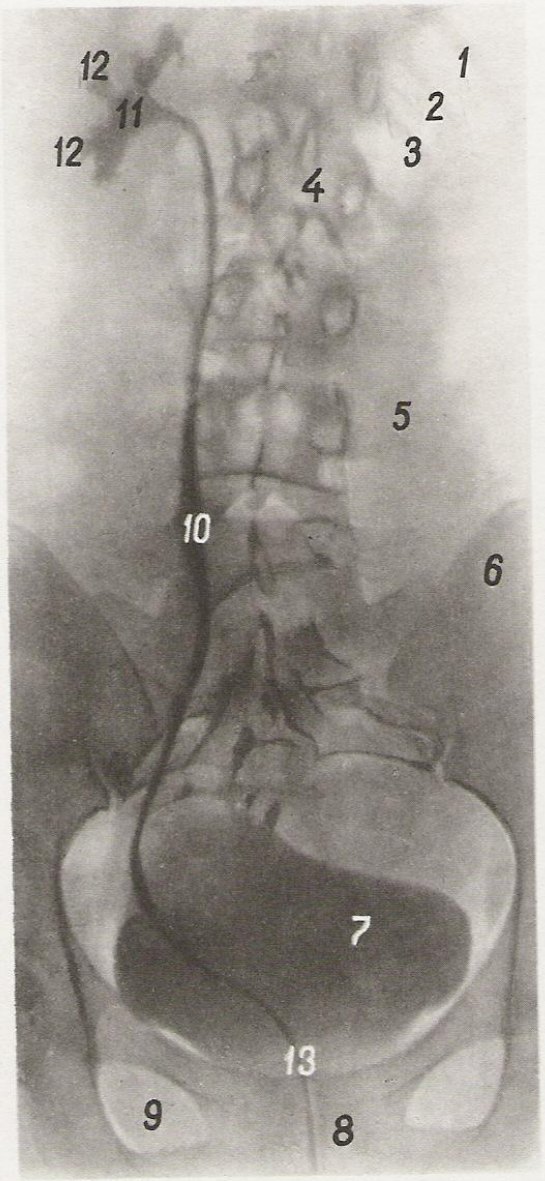
535. *Female urogenital apparatus* (represented semischematically).

(Section of left kidney, uterus, right ovary, part of vagina, right uterine tube, and urinary bladder; the anterior layer of broad ligament of uterus is removed.)



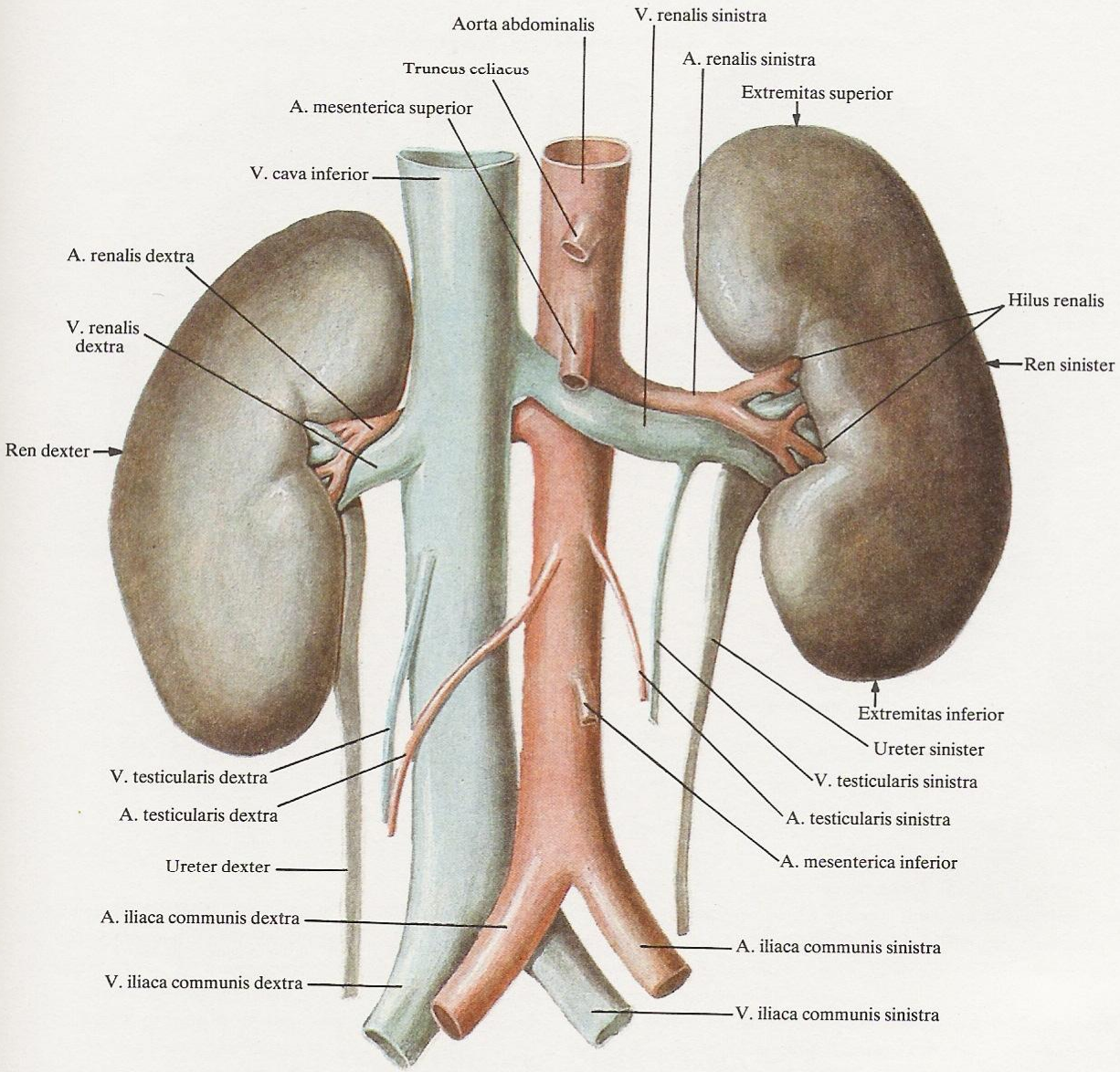
536. *Urinary organs (organa urinaria);* anterior aspect (⅓).

(The parietal peritoneum is removed.)



537. *Pelvis of ureter* (right), *ureter* (right), *and urinary bladder.* (Radiograph.)

1—tenth rib
2—eleventh rib
3—twelfth rib
4—first lumbar vertebra
5—psoas major muscle
6—ilium
7—urinary bladder
8—pubis
9—obturator foramen
10—ureter
11—pelvis of ureter
12—renal calyces
13—catheter introduced through urethra and bladder into orifice of ureter for filling renal calyces, pelvis of ureter, and ureter with contrast medium



538. *Kidneys (renes);* anterior aspect (¾).

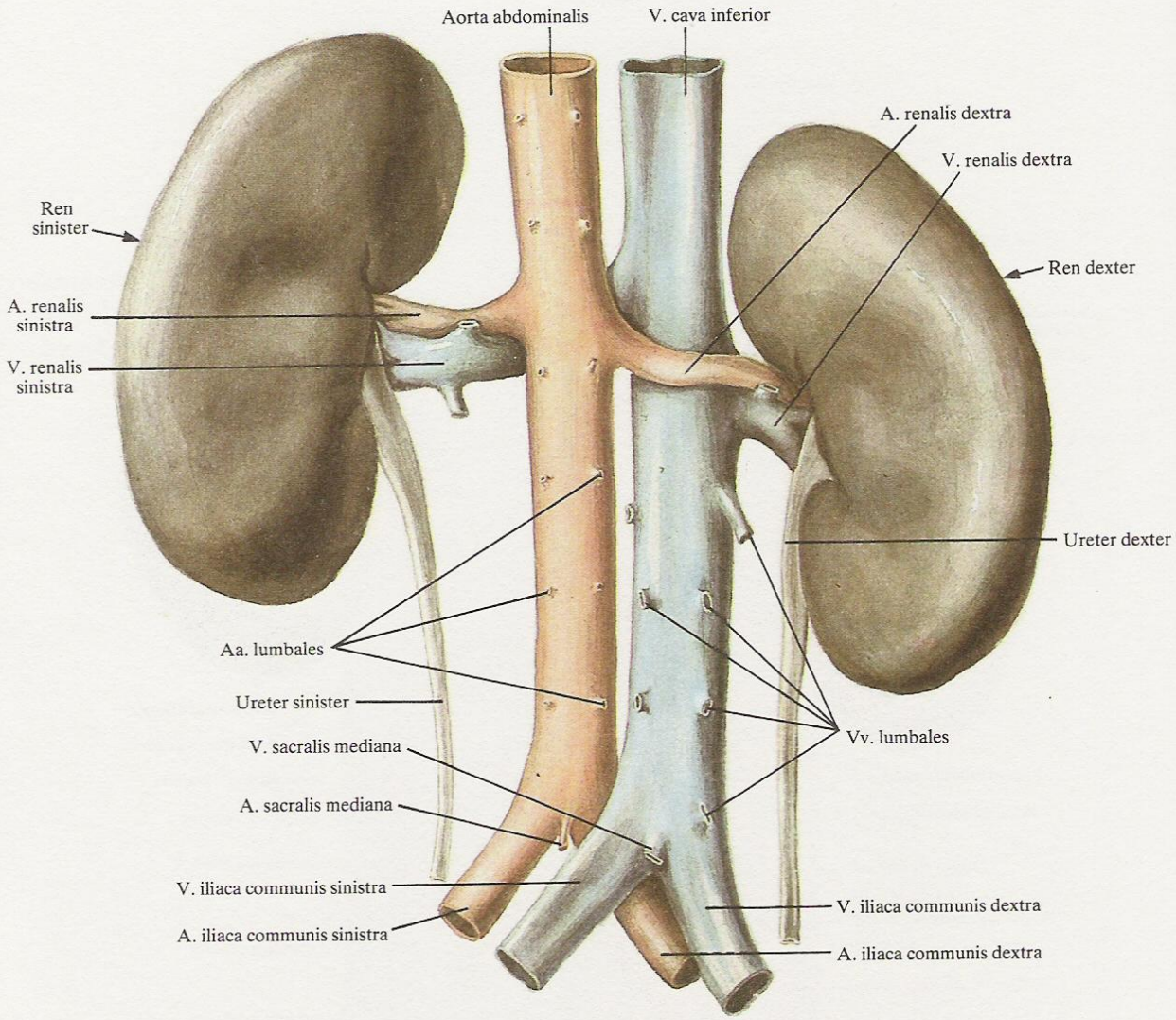
medial margin *(margo medialis)* is concave and directed downwards, medially, and to the front.

In the middle of the medial margin of the kidney is a depression known as the **hilum of the kidney** *(hilus renalis)* which is continuous with the **sinus of the kidney** *(sinus renalis)* (Figs 541, 542, 544). The hilum is formed anteriorly by a narrow anterior lip and posteriorly by a wider posterior lip as a result of which the posterior surface of the kidney is wider than the anterior surface and the sinus of the kidney faces more to the front.

The sinus of the kidney contains the **renal pelvis**, or **the pelvis of the ureter** *(pelvis renalis)*, the **calyces** *(calyces renales)*, branches of the renal vessels and nerves, lymph glands, and fatty tissue. The interrelationship of these structures entering the hilum is such that the veins are situated in front, the arteries and nerves are behind the veins, and the pelvis and ureter are behind the arteries.

The **upper end of the kidney** *(extremitas superior renis)* is wider and flatter then the **lower end** *(extremitas inferior)*. The upper ends carry the suprarenal glands *(glandulae suprarenales)*. These ends are closer to the midplane of the body than the lower ends which are further from the vertebral column.

The following **segments** *(segmenta renales)* are distinguished in each kidney (Figs 546 A, 546 B): the **apical segment** *(segmentum superius)* which corresponds to the medial margin and part of the anterior surface of the upper end of the kidney; the **upper anterior**

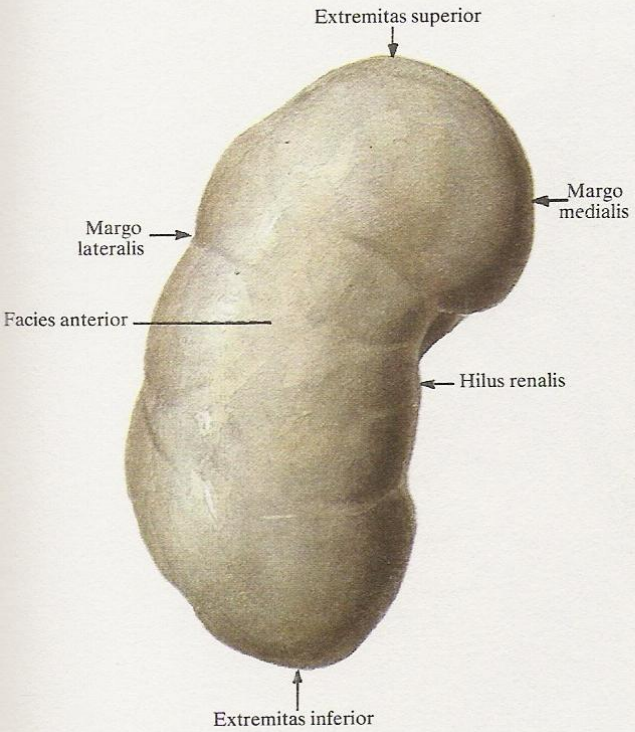


539. *Kidneys (renes);* posterior aspect (¾).

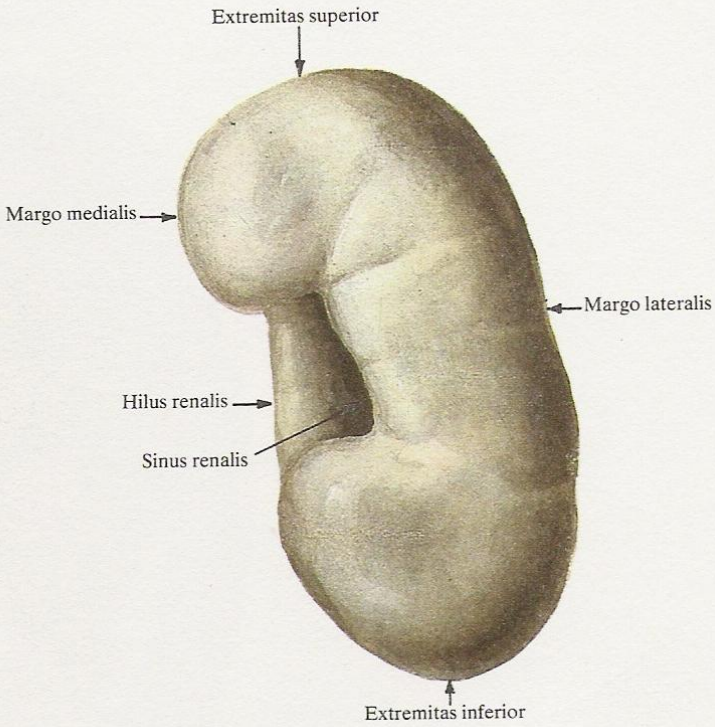
segment *(segmentum anterius superius)*, which is situated in front of the renal pelvis and includes the anterior surface of the upper end and of the upper portion of the middle part of the kidney, the lateral margin, and part of the posterior surface; the **lower anterior segment** *(segmentum anterius inferius)* which is also situated in front of the renal pelvis and extends to the anterior surface of the kidney in the lower part of its middle portion and partly to the posterior surface; the **lower segment** *(segmentum inferius)* which occupies the lower end of the kidney; the **posterior segment** *(segmentum posterius)* which lies behind the renal pelvis and corresponds to the posterior surface of the kidney and is bounded by the apical segment superiorly, the lower segment inferiorly, and the upper and lower anterior segments laterally.

Each kidney is enclosed in renal fat and renal fascia. The **renal fat** *(capsula adiposa)* invests the kidney directly and forms a thicker layer on the posterior surface; it enters the sinus of the kidney via the **hilum**.

The **renal fascia** *(fascia renalis)* is part of the retroperitoneal fascia *(fascia retroperitonealis)*; at the hilum of the kidney it separates to form two laminae: an anterior, or prerenal lamina *(lamina prerenalis)* and a posterior, or retrorenal lamina *(lamina retrorenalis)*. The laminae invest the kidney with the renal fat as well as the suprarenal gland situated on the upper end of the kidney, and the renal vessels and nerves. Medial to the kidney the posterior lamina of the fascia extends on the surface of the vertebral bodies; the anterior lamina is continuous with the contralateral anterior lamina in



540. *Right kidney (ren);* anterior aspect; (¾).



541. *Right kidney (ren);* posterior aspect (¾).
[Entry into sinus of kidney *(sinus renalis)*.]

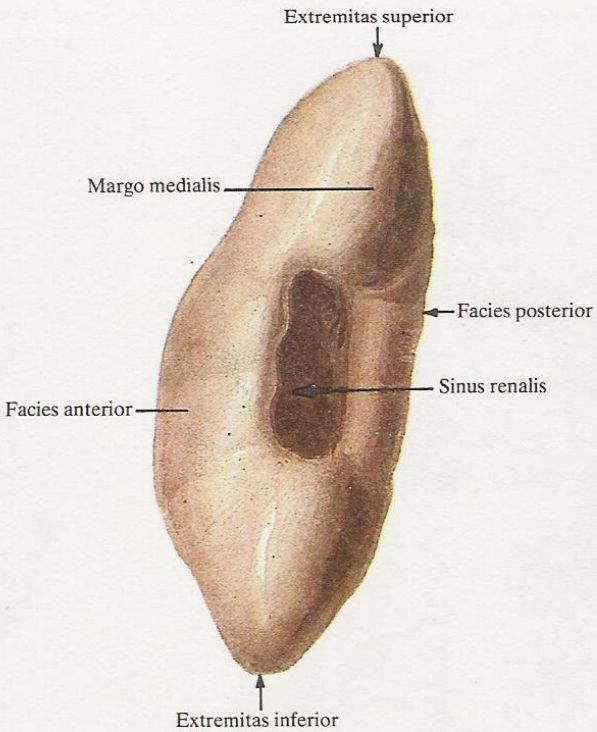
front of the large vessels of the cavity of the abdomen (the inferior vena cava and abdominal aorta). Both laminae fuse in the direction of the upper end of the kidney; inferiorly they do not fuse but are continuous with the subperitoneal fat of the iliac fossa. Connective-tissue bands passing from the renal fascia to the fibrous capsule of the kidney pierce the renal fat.

The kidneys are covered with a dense **fibrous capsule** *(capsula fibrosa)* which is made up of an outer connective-tissue layer and an inner layer of smooth muscles; the fibres of the smooth muscles penetrate the tissue of the kidney. The fibrous capsule is fused loosely with the substance of a healthy kidney and can be removed easily if a cut is made in it.

On section of the kidney (Figs 543, 544) it can be seen that it is composed of medullary and cortical substance differing in density and colour; the medullary substance is denser than the cortical substance and its colour is bluish-red, while the cortical substance is yellowish-red. The difference in colour is due to different blood filling. The medulla occupies the central part of the organ, the cortex—the periphery.

The **medulla of the kidney** *(medulla renis)* (Fig. 544) is not uniform but composed of cone-shaped **renal pyramids** *(pyramides renales)*, 10 to 15 in number. The **base** of each **pyramid** *(basis pyramidis)* faces the surface of the kidney, the apex is directed towards the sinus of the kidney. Small processes of the medullary substance found in the cortex are called the **medullary** (pyramidal) **processes** *(processus medullares)*.

The **cortex of the kidney** *(cortex renis)* is 5 to 7 cm thick and covers the convex base of the pyramids sending processes between them, which are directed at the centre of the kidney. These processes are called the **renal columns** *(columnae renales)* (Fig. 544). In the embryonic period and early childhood pyramids surrounded by cortical substance and called **renal lobes** *(lobi renales)* can be distinctly seen in the kidney. The kidney appears lobulated in these periods. With age, however, the boundaries between the lobes gradually become indistinct but the cortex retains signs of a lobulated structure displayed by **cortical lobules** *(lobuli corticales)*. The apices of two or three (sometimes six) pyramids fuse to form a **renal papilla** *(papilla renalis)* which projects into the sinus of the kidney. There are seven to eight papillae on the average. On the apex of a papilla are 10 to 55 **papillary foramina** *(foramina papillaria)* which form its **cribriform area** *(area cribrosa)*. Each papilla is enclosed by a funnel-shaped **lesser renal calyx** *(calix renalis minor)*; sometimes one lesser calyx embraces two or even three papillae. Several lesser calyces merge to form a **greater renal calyx** *(calix ren-*



542. *Right kidney (ren);* medial margin (¾).
[Sinus of kidney *(sinus renalis)*.]

alis major). There are two or three greater calyces, which fuse to form the pelvis of the ureter *(pelvis renalis)*.

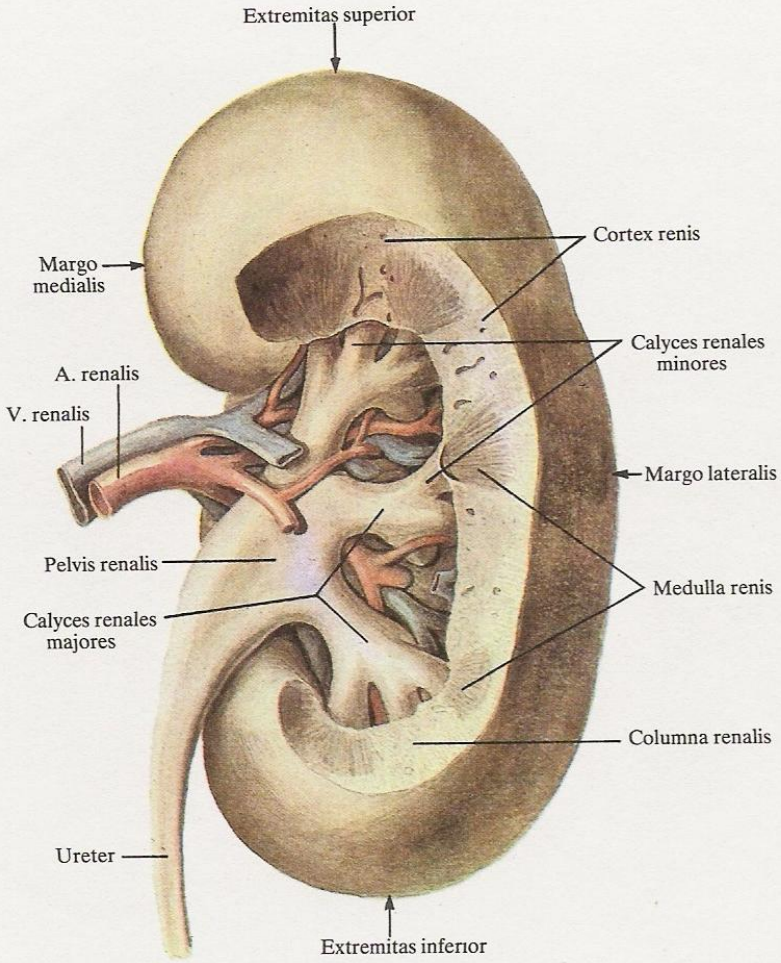
The **pelvis of the ureter,** or **renal pelvis** *(pelvis renalis)* (Figs 543, 544) has the shape of a funnel narrowed in the anteroposterior direction. Its wider part is in the sinus while the narrow part emerges from the hilum of the kidney and is continuous with the ureter. The cavities of the lesser and greater calyces are lined with mucous membrane which is directly continuous with the mucous membrane of the pelvis which in turn is continuous with that of the ureter.

The most important functional part of the renal tissue are epithelial tubes which are called the urinary **renal tubules** *(tubuli renales)*. Each arises in the cortex as a blind sac which encloses like a capsule a tuft of vessels; the tuft together with the capsule is known as the **corpuscle of the kidney** *(corpusculum renis)* (Fig. 545).

In the cortex the urinary tubules bend and twist differently forming the **convoluted renal tubules** *(tubuli renales contorti)*. On leaving the cortex they become relatively straight and are called the **straight renal tubules** *(tubuli renales recti)*. The last-named join into groups in the medulla and drain into the papillary ducts, or **collecting tubules** *(ductus papillares)* which open on the apices of the papillae *(papillae renales)*.

The blood vessels are intimately related with the system of the renal tubules. The branches of the renal artery *(arteria renalis)* passing through the sinus of the kidney *(sinus renalis)* penetrate the renal substance in which they radiate between the pyramids as the **interlobar arteries of the kidneys** *(arteriae interlobares renis)*. On coming closer to the junction between the cortex and medulla, each interlobar artery divides into two **arciform arteries** *(arteriae arcuatae)* which enter the adjacent lobes in which they stretch above the base of the pyramid. They give off **arteriolae rectae** into the medulla and **interlobular arteries** *(arteriae interlobulares)* into the cortex. The interlobular arteries give rise to branches called **vasa afferentia** which break up to form a tuft of capillaries called the **glomerulus**. The tuft is surrounded by the **capsule of the glomerulus** *(capsula glomeruli)* which is the beginning of the renal tubules. The capsule and the glomerulus enclosed in it form the corpuscle of the kidney *(corpusculum renis)*. The capillary network of the glomerulus is purely arterial (of the rete mirabile type). The arteriole which emerges from the glomerulus and stretches outside the capsule is called the **vas efferens**. It also divides to form a network of capillaries which entwines the renal tubules and gives rise to the venous system.

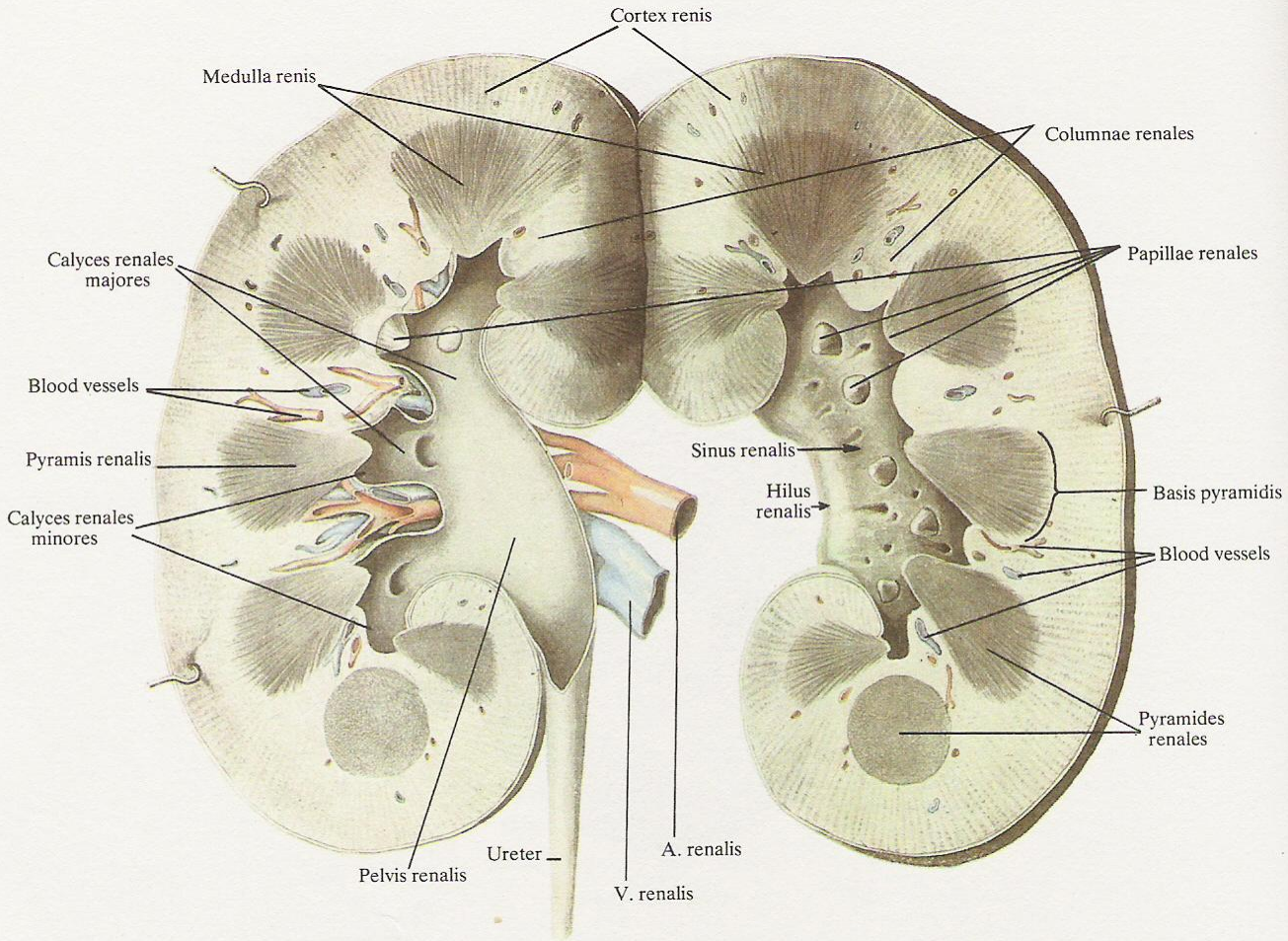
On the whole the veins repeat the course of the arteries in the



543. *Right kidney (ren);* posterior aspect (¾).
(Position of calyces, pelvis of ureter, and vessels in sinus of kidney; renal tissue is partly removed.)

parenchyma of the kidney. Blood from the medulla is collected by the **venulae rectae** draining into the **arcuate veins** *(venae arcuatae)*. The cortex contains the **interlobular veins** *(venae interlobulares)* which follow the course of the interlobular arteries. The interlobular veins form from small vessels of the surface cortical layer which are called the **stellate veins** *(venulae stellatae)* and further receive veins from the secondary capillary network entwining the renal tubules. The interlobular veins drain into the arcuate veins. The arcuate veins of two adjacent lobes fuse to form the **interlobar veins** *(venae interlobares)* stretching through the renal columns together with the interlobar arteries. Around the papillae the interlobar veins emerge from the parenchyma of the kidney into the sinus where they fuse to form the **renal vein** *(vena renalis)* which drains into the inferior vena cava *(vena cava inferior)*.

The right and left kidneys differ in syntopy and skeletopy. The right kidney stretches from the twelfth thoracic to the upper border of the fourth lumbar vertebra, the left kidney—from the eleventh thoracic to the upper border of the third lumbar vertebra. The kidney of a female lies one half vertebra distal to that of a male. In breadth the kidney lies between the lateral border of the psoas major muscle and the posterior border of the transversus abdominis muscle. The upper end of the kidney is closer to the midline than the lower end, i. e. the kidneys are tilted towards each other. The upper end of the posterior surface of the kidney is related to the diaphragm; the posterior surface adjoins the psoas muscle medially and the quadratus lumborum and the transversus abdominis muscles laterally. Both kidneys are situated in front of the twelfth rib which passes obliquely upwards and laterally in relation to their axis. The right kidney is crossed by the twelfth rib at the junction of its upper and middle thirds and only its superolateral part reaches the eleventh rib. The left kidney is crossed by the twelfth rib almost in the middle of its length and its supero-



544. *Right kidney (ren);* section (represened semischematically) (⅘).

[Longitudinal (frontal) section. Renal calyces and pelves of ureters are opened.]

lateral portion is situated slightly above the level of the eleventh rib.

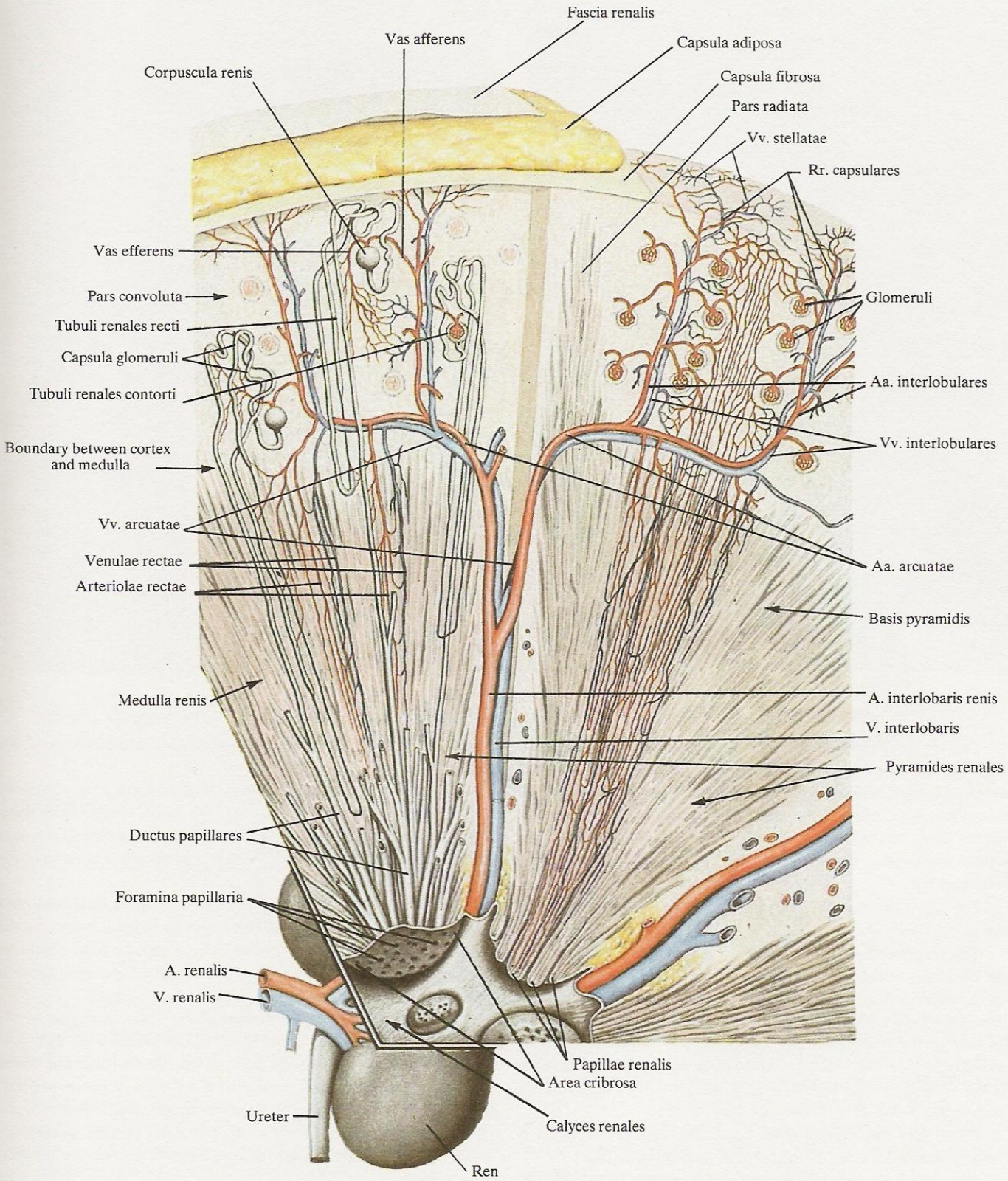
The right suprarenal gland lies directly on the upper end of the right kidney. Two-thirds of the anterior surface of the right kidney is in relation with the right lobe of the liver, below this level it is related to the right flexure of the colon. The medial surface and the hilum adjoin the second part of the duodenum. The anterior surface of the right kidney is covered by the peritoneum only where it is in contact with the liver.

The left suprarenal gland is situated on the upper end of the left kidney. The upper third of the anterior surface of the left kidney is in relation with the posterior wall of the stomach, the middle third is related to the tail of the pancreas which crosses transversely the hilum of the kidney. The upper half of the lateral border of the left kidney is in contact with the spleen. The lower third of the anteromedial portion of the left kidney faces the left mesenteric sinus and comes in contact here with the loops of the jejunum. The anterolateral part of the kidney is related to the left flexure of the colon. The parts of the anterior surface of the left kidney which are in relation with the stomach, spleen, and jejunum are covered by the peritoneum.

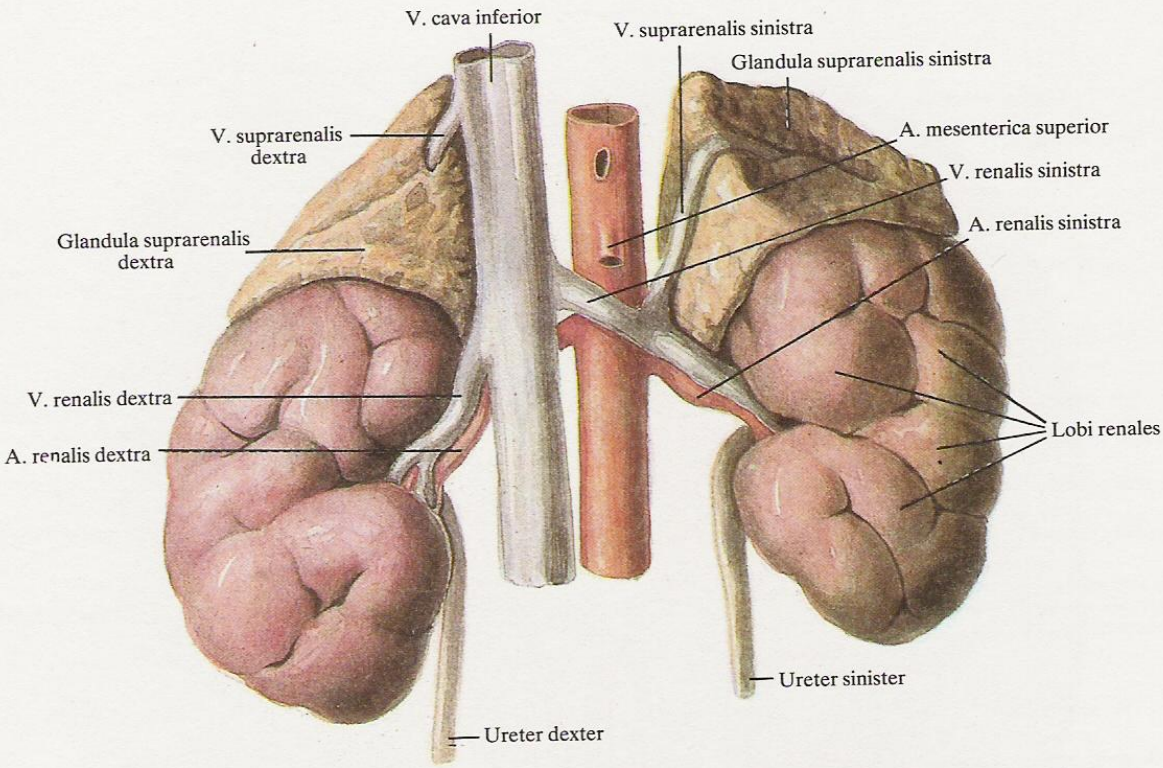
A variety of developmental anomalies and malposition of the kidneys are encountered. The position of the right kidney varies particularly due to descent of the colon. A single kidney is sometimes encountered instead of two kidneys; it is situated in the pelvis. An arched, or horseshoe kidney *(ren arcuatus)* occurs sometimes as a result of fusion of the lower ends of both kidneys.

Innervation: the coeliac and renal plexus *(plexus celiacus* et *renalis)*.

Blood supply: the renal artery *(arteria renalis)*.



545. *Arrangement of renal tubules and vessels in kidney* (diagram).



546. *Kidneys (renes) and suprarenal glands (glandulae suprarenales);* anterior aspect (3/2).
(Child's lobulated kidneys.)

THE URETERS

The **ureter** (Figs 534–539) is a paired retroperitoneal tubular organ by means of which the renal pelvis communicates with the urinary bladder. The ureter measures 30 to 35 cm in length but varies in diameter, which is 3–4 mm at its origin from the renal pelvis, on entry into the true pelvis, and where it passes through the wall of the bladder; between these narrowed portions the diameter reaches 9 mm.

Two parts of the ureter are distinguished: the abdominal and the pelvic part.

The **abdominal part** *(pars abdominalis)* forms a flexure at its origin from the renal pelvis. It turns downwards and medially to pass on the anterior surface of the psoas major muscle to the arcuate line of the pelvis. The **pelvic part** *(pars pelvina)* lies under the peritoneum of the true pelvis and then curves to the front, medially and downwards. On reaching the base of the urinary bladder the ureter pierces its wall obliquely and opens into the cavity of the bladder by means of a slit-like opening.

The wall of the ureter is made up of three layers: a connective-tissue adventitious coat, muscular coat, and mucous coat.

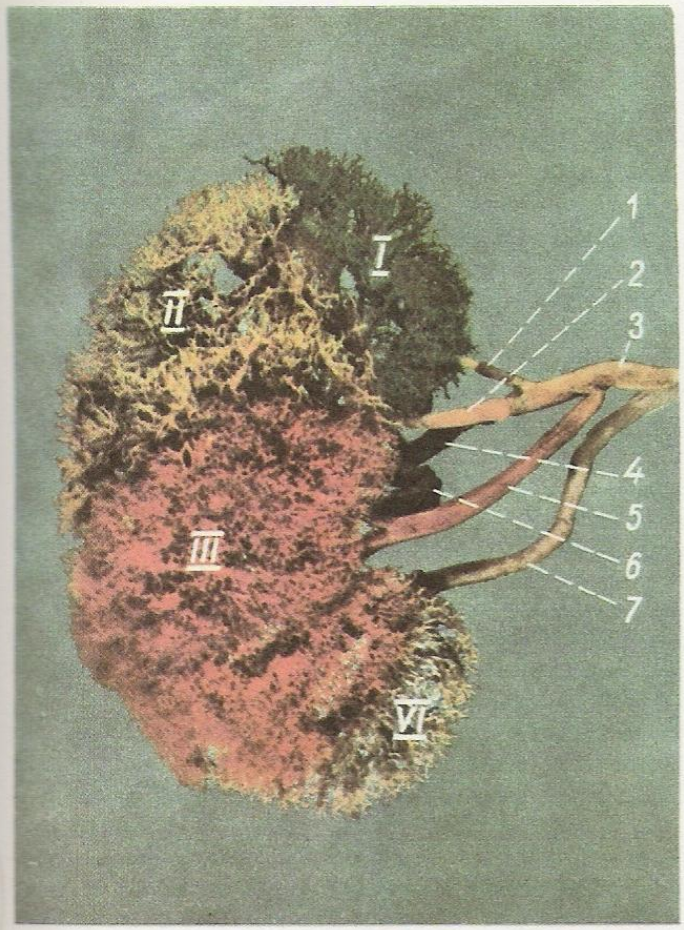
The **adventitious coat** *(tunica adventitia)* consists of fibrous connective tissue with an admixture of elastic fibres. Nerves and vessels of the ureter pass in the connective tissue. The ureter is invested in poorly developed fascia which is a continuation of the renal fascia.

The **muscular coat** *(tunica muscularis)* has three layers: an inner longitudinal, a middle circular, and an outer longitudinal layer. The last-named is not a continuous layer but consists of separate bundles, the greater number of which is in the lower portion of the ureter.

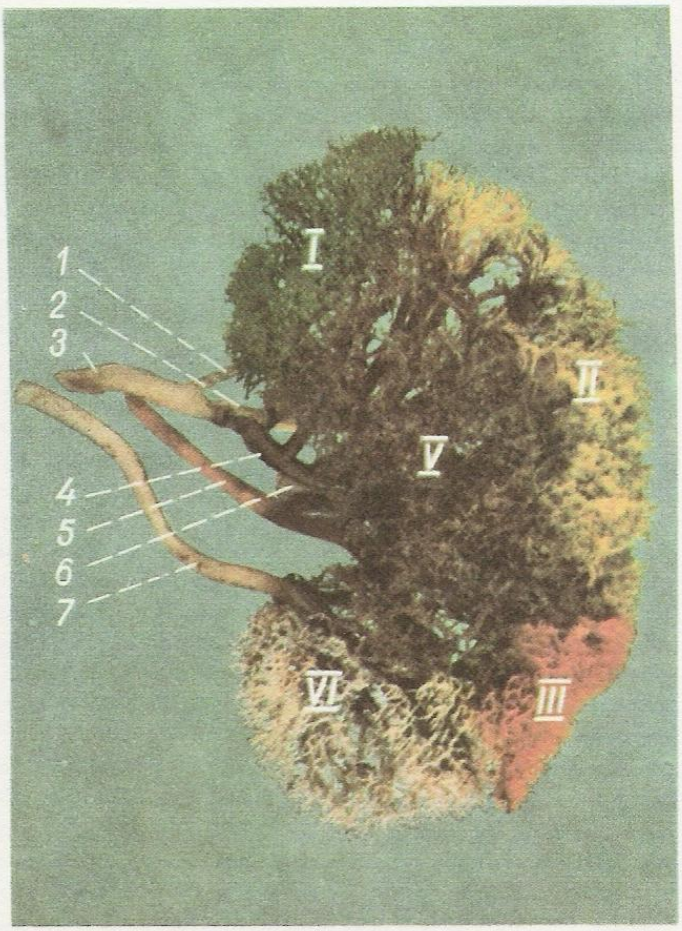
The **mucous coat** *(tunica mucosa)* forms longitudinal folds as a result of which the lumen of the ureter is stellate; nearer to the lower portions the folds are smoothed out and the lumen loses its stellate shape. A few small tubulo-alveolar glands occur in the mucous coat, mainly in the upper portion of the ureter.

The topographical relationships of the abdominal part of the right and left ureters differ. The initial portion of the right ureter is behind the second part of the duodenum. The lower portion of its abdominal part crosses the root of the mesentery. It enters the true pelvis in front of the common iliac vessels. The initial portion of the left ureter passes behind the duodenojejunal flexure. On entry into the true pelvis it crosses the external iliac vessels.

In the middle or upper third of their course the right and left ureters cross the testicular (or ovarian) vessels.



546A. *Segments of right kidney;* anterior aspect (specimen prepared by M. Burykh). (Photograph of polychromatic corrosion specimen.)



546B. *Segments of right kidney;* posterior aspect (specimen prepared by M. Burykh). (Photograph of polychromatic corrosion specimen.)

I—apical segment, territory of renal parenchyma supplied with blood by apical segmental artery
II—upper anterior segment, territory of renal parenchyma supplied with blood by upper anterior segmental artery
III—lower anterior segment, territory of renal parenchyma supplied with blood by lower anterior segmental artery
IV—lower segment, territory of renal parenchyma supplied with blood by lower segmental artery
V—posterior segment, territory of renal parenchyma supplied with blood by posterior segmental artery

1—apical segmental artery
2—upper anterior segmental artery
3—trunk of renal artery
4—posterior segmental artery
5—lower anterior segmental artery
6—renal vein
7—lower segmental artery (lower "accessory" renal artery to lower end of kidney)

The topographical relationships of the pelvic part of the right and left ureters are the same, but differ in males from those in females.

Before entering the bladder, the male ureter is crossed by the vas deferens which lies medially of it here; the site of entry into the bladder is slightly below the floor of the retrovesical pouch and corresponds to the apex of the seminal vesicle.

Descending on the wall of the true pelvis, the female ureter crosses the initial part of the uterine artery superficially and then stretches medially, downwards, and to the front in the para-uterine fat where at the level of the neck of the uterus it is crossed by the uterine artery. Still more to the front the ureter crosses the antero-lateral wall of the vagina and enters the urinary bladder.

Innervation: the renal, hypogastric, testicular (ovarian), and ureteric plexus [*plexus renalis, hypogastricus, testicularis (ovaricus)* et *uretericus*].

Blood supply: the renal and testicular (ovarian) arteries [*arteriae renalis* et *testicularis (ovarica)*].

THE URINARY BLADDER

The **urinary bladder** *(vesica urinaria)* (Figs 534–537, 547–549, 562, 563) is a hollow muscular organ of a flattened spherical shape situated in the cavity of the true pelvis directly behind the pubic symphysis. The size and shape of the bladder change depending on the amount of urine filling it. A bladder filled with urine is pear-shaped. Its wide part is directed upwards and to the back, the narrow part faces downwards and to the front. An empty bladder with relaxed walls has the shape of a saucer. The capacity of the bladder is 750 cm^3 on the average.

The urinary bladder has several parts continuous with one another. The main part is the **body of the bladder** *(corpus vesicae)*. The superoanterior part is the **apex of the bladder** *(apex vesicae)* which is easily distinguished in a filled bladder. It is continuous superiorly in the direction of the umbilicus with the **median umbilical ligament** *(ligamentum umbilicale medianum)* connecting the urinary bladder with the umbilicus. This ligament is the obliterated **urachus**. The posteroinferior part of the bladder which faces the rectum in a male (or the vagina in a female) is the **base of the bladder** *(fundus vesicae)* (Figs 548, 563), the least mobile part. The anteroinferior elongated part is the **neck of the bladder** *(cervix vesicae)* containing the **internal urethral orifice** *(ostium urethrae internum)*.

The anterior, posterior, and lateral walls are distinguished in the urinary bladder. The anterior wall corresponds to the area between the apex and neck; it faces the pubic symphysis, and when the bladder is filled it is situated behind the muscles of the anterior abdominal wall, namely the pyramidalis and rectus abdominis muscles. The posterior wall faces upwards into the cavity of the abdomen and is covered by the peritoneum.

The wall of the bladder consists of smooth muscular tissue and its cavity is lined with a mucous membrane. The bladder is covered partly by a connective-tissue coat and partly by a serous coat (peritoneum).

The **muscular coat** *(tunica muscularis)* is rather thick and made up of three layers (outer, middle, and inner) which merge with one another without distinct boundaries.

The outer longitudinal layer *(stratum externum)* begins on each side of the pubic symphysis from the inferior pubic ramus by the **pubovesical muscle** *(musculus pubovesicalis)*. This muscle runs back to the neck of the bladder and then on the inferior and posterior surfaces to the apex; when passing on the posterior surface of the bladder it gives off to the muscular coat of the rectum in males a paired **rectovesical muscle** *(musculus rectovesicalis)*. The analogous muscle in females passes to the neck of the uterus and from its posterior surface to the rectum and sacrum as the **rectouterine muscle** *(musculus rectouterinus)*.

The next, middle muscular layer of the bladder is situated deeper and is the strongest. It is the main component of the muscular wall. It is formed of circularly running (in the horizontal plane) bundles. In the region of the neck it forms the muscular sphincter of the urinary bladder.

The deepest, inner layer is the weakest. It consists of muscular fibres running longitudinally and partly obliquely and is developed only in the region of the base of the bladder.

The degree of development of the three muscular layers varies in the different areas of the bladder, while the muscular fibres running obliquely from one layer into another make the boundaries between them indistinct. Due to the irregular development of the layers some areas of the wall of a considerably stretched bladder may become thin and the overlying mucous coat is stretched out.

The **mucous coat** *(tunica mucosa)* consists of stratified transitional epithelium and has a **submucous coat** *(tela submucosa)*. The submucous coat is rich in fibrous connective tissue and pierced by fine and thick elastic fibres, as a result of which numerous folds form which repeat the contours of the muscular layer. In a filled bladder the folds are smoothed out.

In the anterior part of the base of the bladder are three openings: two **orifices of the ureters** *(ostia ureterum)* and one **internal urethral orifice** *(ostium urethrae internum)*. They are arranged in the angles of a triangular area called the **trigone of the bladder** *(trigonum vesicae)* which is the least changeable and most firmly fixed area of the bladder (Fig. 549). Within the boundaries of this triangle the mucous coat is devoid of the submucous coat and is fused intimately with the muscular coat forming no folds. The **orifices of the ureters** *(ostia ureterum)* form the right and left upper angles of the triangle. They are connected by the **ureteric fold** *(plica interureterica)* formed by the muscular fibres running from both ureters. At the apex of the triangle, which is situated anteriorly and inferiorly, is the crescent **internal urethral orifice** *(ostium urethrae internum)*. To the back of the orifice the mucous membrane forms an elevation called the **uvula of the bladder** *(uvula vesicae)* (Fig. 549) which is continuous with the **urethral crest** *(crista urethralis)*.

The superoposterior and partly the lateral surfaces of the urinary bladder are covered by the peritoneum. The **transverse vesical fold** *(plica vesicalis transversa)* forms where the peritoneum passes from the bladder to the posterior surface of the anterior abdominal wall. Posteriorly, on the level of the orifices of the ureters the peritoneum passes from the bladder to the rectum in males and to the uterus in females. The anterior, extraperitoneal, surface of the bladder is related to the pubic symphysis and superior pubic rami from which it is separated by a sheet of prevesical fascia. A filled bladder extends upwards from under the pubic symphysis behind the rectus abdominis muscles.

The base of the bladder in males is related to the seminal vesicles, the vasa deferentia, and partly the prostate; in the space between the seminal vesicles, the anterior wall of the ampulla of the rectum is separated from the base of the bladder by the peritoneum of the rectovesical pouch.

In females the base of the bladder is in relation with the neck of the uterus and the anterior wall of the vagina. The anteroinferior part of the bladder is in contact with the posterior portion of the superoanterior surface of the prostate in males and the urogenital diaphragm in females. The lower portions of the lateral walls

of the bladder, which are subperitoneal, partly come in contact with the floor of the pelvis; when the bladder is filled they come in contact with the obturator muscles; these portions are related to the vasa deferentia in males and the round ligaments of the uterus in females.

Innervation: the hypogastric and pelvic plexuses (*plexus hypogastrici superior* et *inferior*).

Blood supply: the vesical and middle rectal arteries (*arteriae vesicales* et *rectalis media*) in males; the uterine artery *(arteria uterina)* in females.

THE GENITAL ORGANS

The **male genital organs** *(organa genitalia masculina)* and the **female genital organs** *(organa genitalia feminina)* are differentiated due to the specific features of development, structure, and function. The reproductive gland, or gonad, is the organ which determines the sex of a person. In males this is the testis and in females the ovary *(ovarium)*. They are glands of mixed secretion. Like in the exocrine glands, germ, or sex cells (gametes) are produced in them (spermatozoa in the males and ova in the females), secreted, and are responsible for the reproduction process. Like the endocrine glands, the gonads produce sex hormones which enter the blood and influence the development of secondary sex characters and the function of the genital organs.

The genital organs, both male and female, are separated into internal and external.

THE MALE GENITAL ORGANS

Internal and external male genital, or reproductive, organs are distinguished. The **internal male genital organs** *(organa genitalia masculina interna)* are: the testis, the epididymis, the vas deferens *(ductus deferens)*, the seminal vesicle *(vesicula seminalis)*, the spermatic cord *(funiculus spermaticus)*, and the prostate *(prostata)*. The **external male genital organs** *(organa genitalia masculina externa)* are as follows: the penis, the male urethra *(urethra masculina)*, and the scrotum.

THE INTERNAL MALE GENITAL ORGANS

THE TESTIS

The testis (Figs 547, 550–554) is a paited gland situated in the lower part of the scrotum (see *The Reproductive Glands*, Vol. III).

It is an ellipsoid organ whose lateral and medial surfaces are slightly flattened. It measures 4.5 cm in length on the average, 3 cm in width, 2 cm in thickness, and weighs 25 to 30 g.

The testis has a **medial** and **lateral surfaces** (*facies medialis* et *lateralis*), which are continuous one with the other, a **front** and **posterior border** (*margo anterior* et *posterior*), and an **upper** and **lower extremity** (*extremitas superior* et *inferior*).

The testis is suspended on the spermatic cord (the left gland lower than the right) by its posterior border so that its upper extremity is tilted forwards and its lateral surface slightly to the back.

The posterior border bears the epididymis.

The testis is made up of parenchyma enclosed in a dense connective-tissue **tunica albuginea**; the **septa of the testis** *(septula testis)* (Fig. 553) stretch from it into the parenchyma and divide the gland into **lobes of the testis** *(lobuli testis)*. The septa run radially from the front border and medial and lateral surfaces to the posterior border of the testis and fuse in the upper part of the border to form the **mediastinum testis**. The mediastinum (Fig. 553) is a wedge-like thickening of the tunica albuginea and has a spongy structure. The lobes of the testis vary in number from 100 to 250 and are conical with the apex facing the mediastinum.

Each lobe contains three or four **convoluted seminiferous tubules** *(tubuli seminiferi contorti)* which measure 70 to 100 cm in length and 140 μm in diameter.

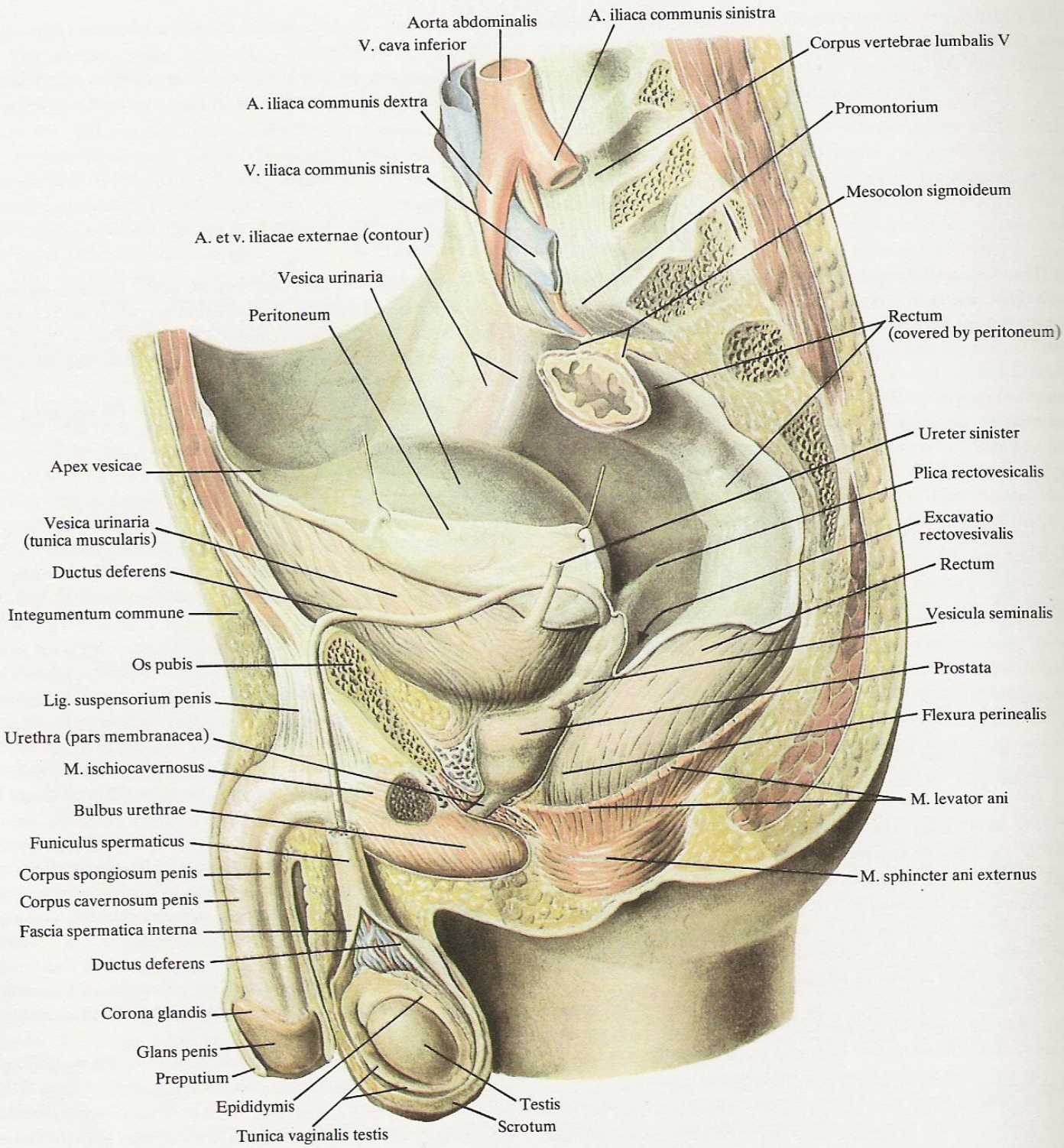
The convoluted tubules contain germ-forming cells (spermatogonia) from which spermatozoa develop. At the apex of the lobe three or four convoluted tubules unite to form the **straight seminiferous tubules** *(tubuli seminiferi recti)*. On entering the mediastinum testis, the straight tubules anastomose to form a network called the **rete testis**.

Up to 18 **efferent ductules** *(ductuli efferentes testis)* arise from the rete in the mediastinum, which pierce the tunica albuginea and enter the head of the epididymis.

The testis with the epididymis are invested in the **tunica vaginalis testis** which forms a closed serous cavity around them. Like all the intraperitoneal organs, the testis is directly covered by the **visceral layer** *(lamina visceralis)* which is continuous with the **parietal layer** *(lamina parietalis)* of the tunica vaginalis along the posterior border of the testis.

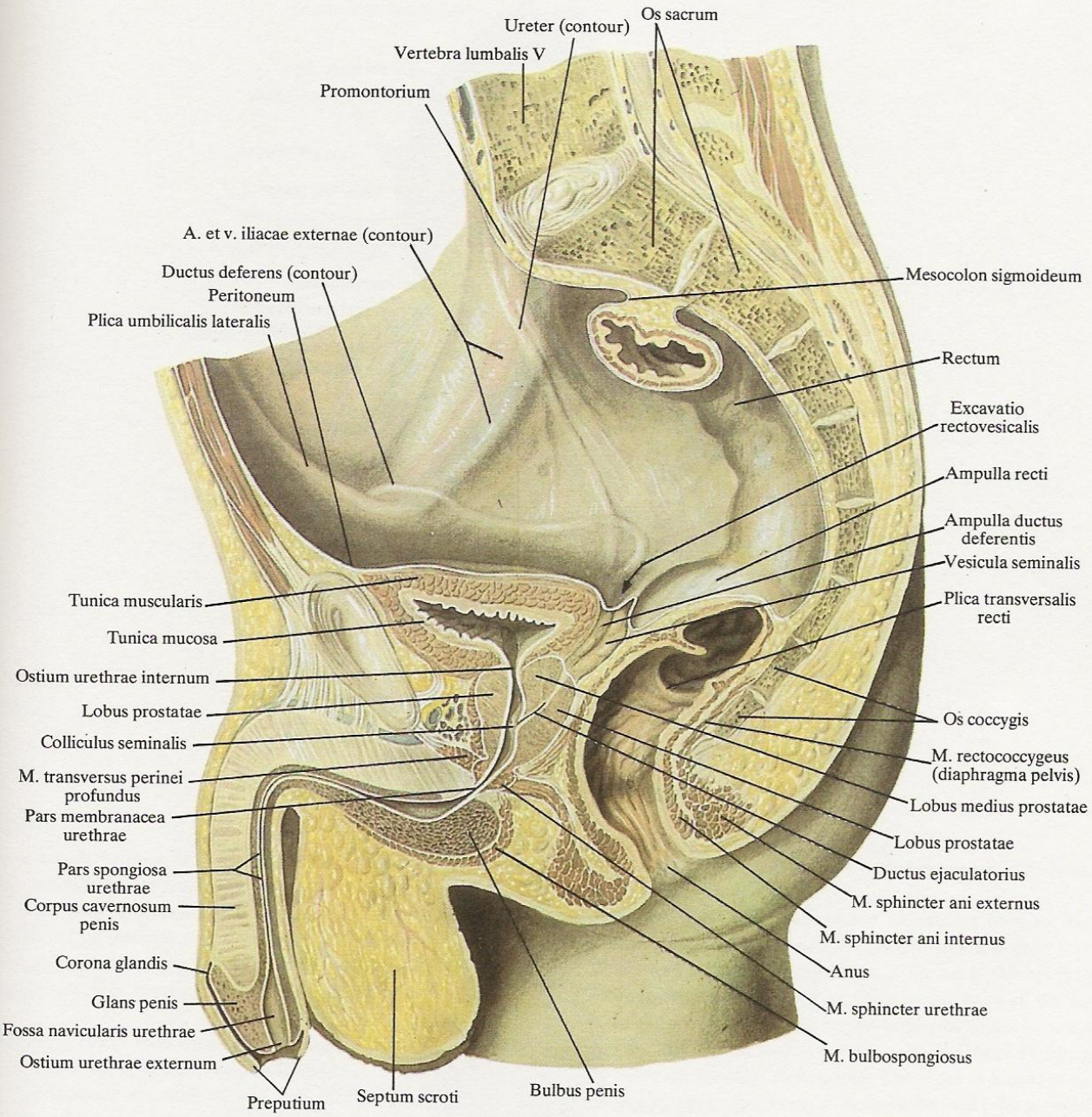
The visceral layer is intimately fused with the tunica albuginea for its entire length, except for an area on the posterior border which it leaves uncovered before passing over to the epididymis; nerves and vessels enter the testis through this area (Fig. 554).

The **epididymis** (Figs 547, 550–554) is an elongated paired structure situated along the posterior borders of the right and left



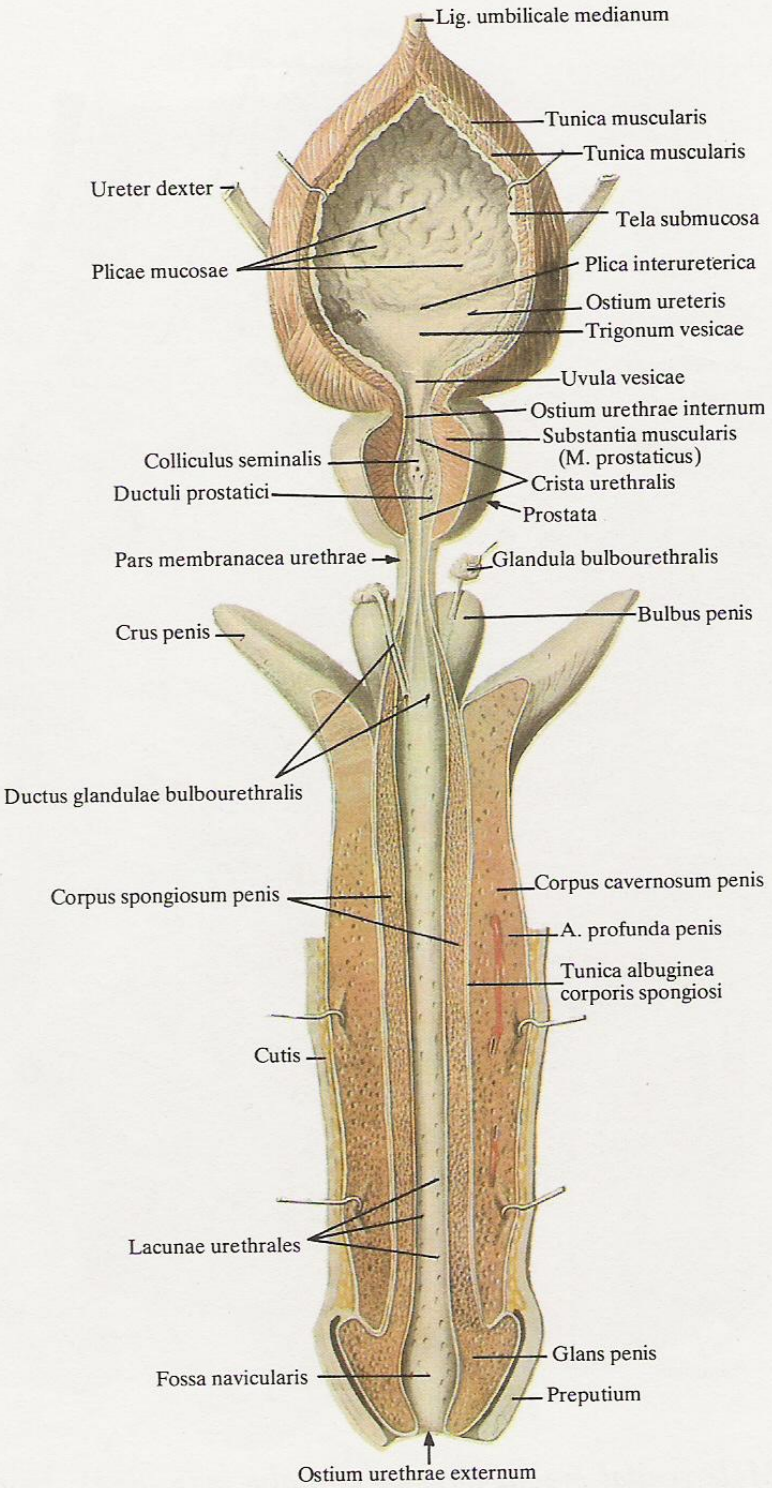
547. *Male genital organs (organa genitalia masculina);* left aspect (⅔).

(Left parts of the walls of the pelvis are removed.)



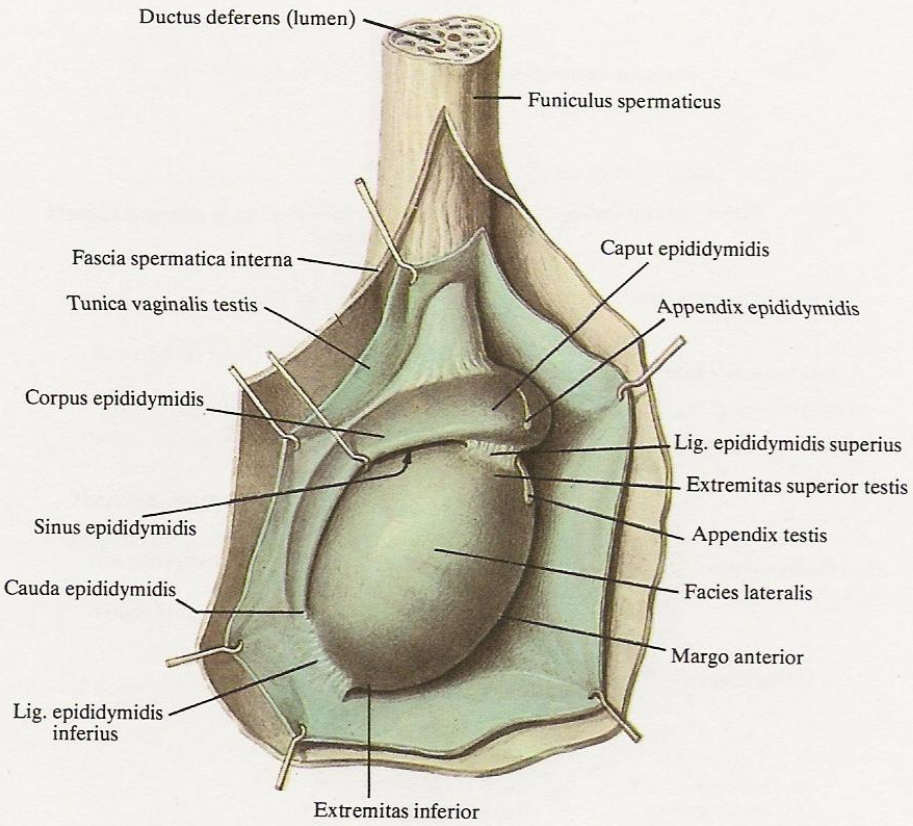
548. *Male genital organs (organa genitalia masculina);* from left side (⅔).

(Midsagittal section, right side.)



549. *Male genital organs; urinary bladder, prostate, and corpora cavernosa* (½).

(The bladder and urethra are opened.)



550. *Right testis and epididymis;* lateral aspect (1/1).
(The tunica vaginalis testis is coloured blue.)

testes. It forms the main bulk of the efferent ducts. It has an upper part—the **head of the epididymis** *(caput epididymidis)* which is wide, rather blunt and projects above the upper extremity of the testis, a trihedral middle thinnest part—the **body of the epididymis** *(corpus epididymidis)*, and a lower part—the **tail of the epididymis** *(cauda epididymidis)* which is continuous with the **vas deferens** *(ductus deferens)*.

The head of the epididymis is composed of **lobules of the epididymis** (*lobuli epididymidis* s. *coni epididymidis*).

A rudimentary connective-tissue structure is sometimes found attached to the head of the epididymis and is called the **appendix of the epididymis** *(appendix epididymidis)*, or on the upper end of the testis, in which case it is called the **appendix of the testis**. A remnant of the mesonephros sometimes occurs above the head; this is a small structure called the **paradidymis** which is made up of convoluted tubules.

Blind pouches called the **ductuli aberrantes** (*superior ductulus abberans* s. *ductulus abberans superior*) which have lost their connection with the vas deferens may be encountered in the epididymis.

The epididymis is covered by the visceral layer of the tunica vaginalis of the testis; since the serous layer penetrates between the body of the epididymis and the testis, a slit-like **sinus of the epididymis** *(sinus epididymidis)* forms here. The sinus is bounded above and below by serous folds called the **superior** and **inferior epididymal ligaments** (*ligamenta epididymidis superius* et *inferius*).

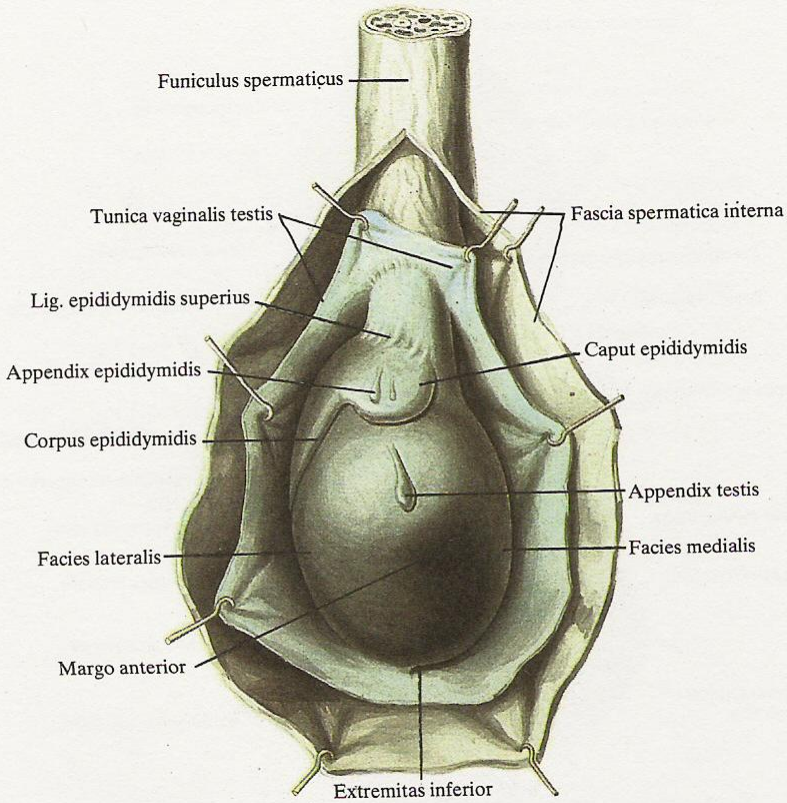
Innervation: the coeliac, renal, aortic, and hypogastric plexuses (*plexus celiacus, renalis, aorticus* et *hypogastricus*).

Blood supply: the testicular artery *(arteria testicularis)*.

THE VASA DEFERENTIA

The **vasa deferentia** *(ductus deferentes)* (Figs 547, 555, 556) are a pair of dense tubes measuring up to 50 cm in length, 3 mm in diameter and with a lumen of 0.5 mm, arising from the lower end of the tail of the epididymis and opening together with the seminal vesicles into the prostatic part of the urethra.

The vas deferens is made up of several parts. The first part,



551. *Right testis and epididymis;* anterior aspect (1/1).

which is situated in the epididymis, is a greatly convoluted cylindrical tube.

The second part stretches as a component of the spermatic cord in the scrotum and then in the inguinal canal, subperitoneally, to the base of the bladder. It is an even white-coloured cylindrical tube.

The terminal part is dilated and called the **ampulla of the vas deferens** *(ampulla ductus deferentis)*. Its wall is marked by sac-like cavities which are called the **diverticula of the ampulla** *(diverticula ampullae)* and make the outer surface uneven.

The end part of the vas deferens narrows again and unites with the **excretory duct of the seminal vesicle** *(ductus excretorius vesiculae seminalis)* to form the **ejaculatory duct** *(ductus ejaculatorius)* (Fig. 556).

The vas deferens has an outer adventitious coat, a middle muscular coat, and an inner mucous coat. The **adventitious coat** *(tunica adventitia)* is formed of connective tissue with an admixture of elastic fibres and carries the vessels and nerve elements of the duct. The **muscular coat** *(tunica muscularis)* is the thickest part of the wall and consists of longitudinal outer and inner layers and a circular middle layer of smooth muscles. The **mucous coat** *(tunica mucosa)* is gathered in longitudinal folds and covered with double-layer prismatic epithelium overlying a connective-tissue lamina propria which is also rich in elastic fibres.

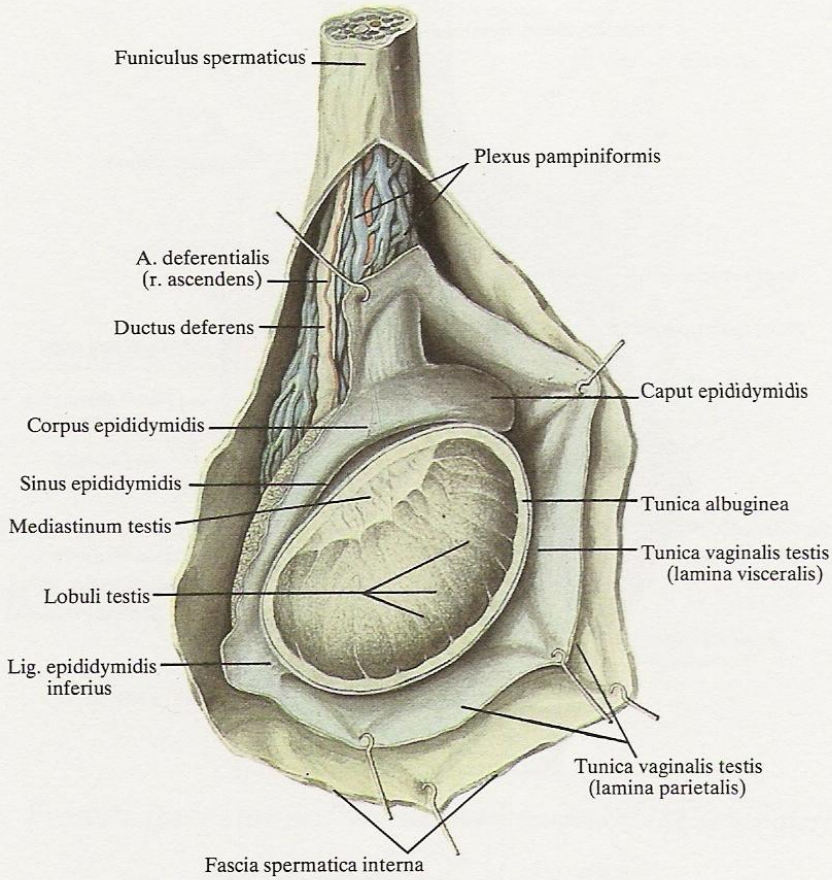
THE SPERMATIC CORDS

The **spermatic cord** *(funiculus spermaticus)* (Figs 550–553) is a paired rounded band measuring up to 18–20 cm in length.

The spermatic cord runs from the deep inguinal ring to the posterosuperior periphery of the testis. It suspends the testis and raises it to the inguinal canal by means of the cremaster muscle (see Vol. I, Fig. 304) enclosed in it.

The spermatic cord contains the vas deferens, the testicular artery, the venous pampiniform plexus, the lymph vessels of the testis, and the nerves, arteries, and veins of the vas deferens.

The components of the spermatic cord are enclosed into the common **coats of the spermatic cord and testis** (*tunicae funiculi spermatici* et *testis*). Their inner layer, which corresponds to the



552. *Right testis and epididymis;* lateral aspect (1/1).

[The tunica albuginea and tunica vaginalis testis (its visceral layer) are partly removed.]

transversalis fascia of the abdomen, is called the **internal spermatic fascia** *(fascia spermatica interna)*.

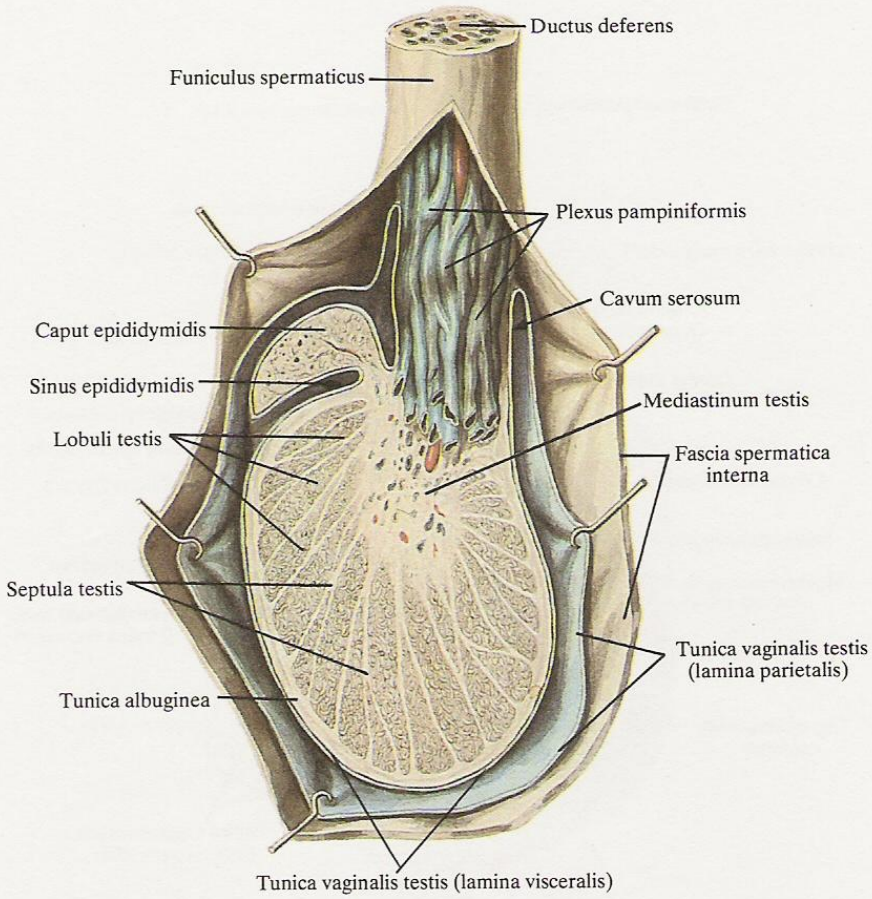
The **cremaster muscle** *(musculus cremaster)* which raises the testis lies on this common coat. Its bundles are bound by connective-tissue fibres forming the **cremaster fascia** *(fascia cremasterica)*. The fascia together with the muscle and the adjoining tissues is enclosed in the **external spermatic fascia** *(fascia spermatica externa)* which is a continuation of the intercrural fibres *(fibrae intercrurales)* of the aponeurosis of the external oblique muscle of the abdomen.

On emerging from the superficial inguinal ring part of the spermatic cord lies in the scrotum, which structure is described below.

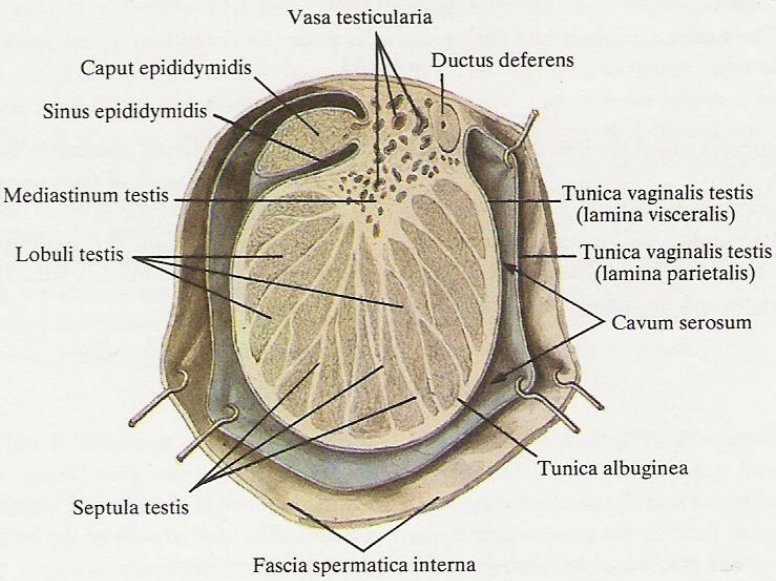
THE SEMINAL VESICLES

The **seminal vesicle** *(vesicula seminalis)* (Figs 547, 555, 556) is a paired organ situated behind and to both sides of the base of the bladder, in front of the rectum. It is a sacculated blind tube measuring up to 12 cm in length and 6–7 mm in thickness which forms several coils (genua) packed together and bound by connective tissue. When uncoiled (not separated) the seminal vesicle has the appearance of an elongated body rather flattened in the anteroposterior direction and measuring up to 5 cm in length, up to 2 cm in width, and 1 cm in thickness. A wide part facing upwards and laterally, and a narrow part facing downwards and medially and called the **duct of the seminal vesicle** *(ductus excretorius)* are distinguished. The medial wall of the vesicle facing the duct is thicker than the lateral wall.

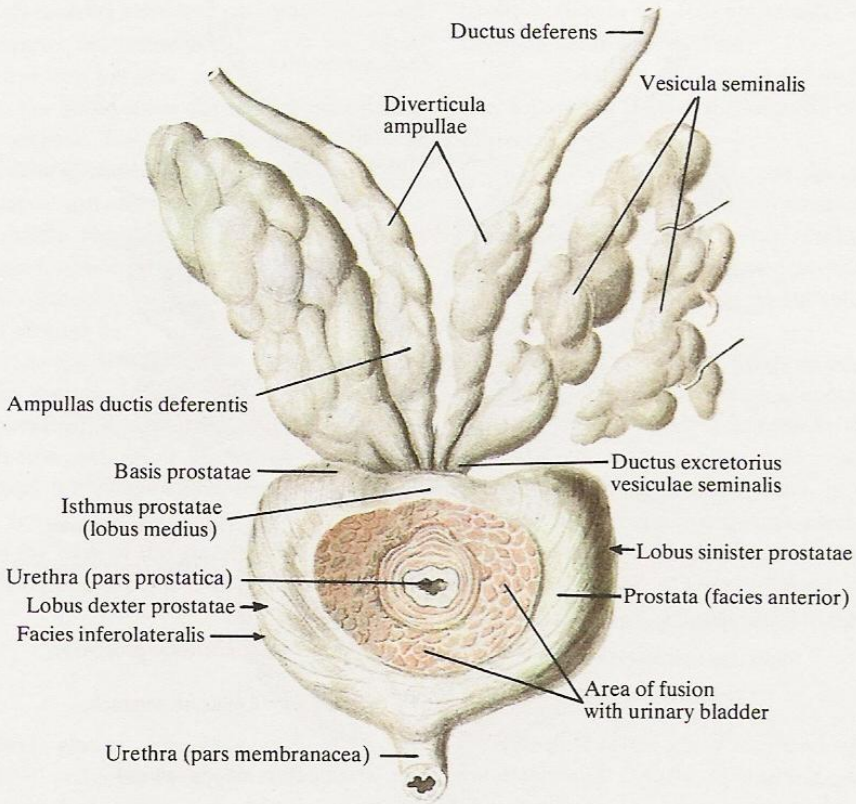
The cavity of the seminal vesicle is a tortuous canal with lateral pockets which form a labyrinth on section. The wall is composed of elastic, smooth-muscle, and collagen fibres forming the **muscu-**



553. *Testis and epididymis* (1/1).
(Longitudinal section.)



554. *Testis and epididymis* (3/2).
(Transverse section.)



555. *Prostate (prostata) and seminal vesicles (vesiculae seminales);* anterior aspect (1/1).

(The left seminal vesicle is dissected.)

lar coat *(tunica muscularis)*. The cavity is lined by a **mucous coat** *(tunica mucosa)* forming elevations of various shape which sometimes fill the lumen of the vesicle. Each seminal vesicle is enclosed in an **adventitious coat** *(tunica adventitia)*.

The anterior surface of the seminal vesicle is related to the base of the bladder, the posterior surface—to the ampulla of the rectum from which it is separated by the rectovesical septum. Medial to the vesicle is the ampulla of the vas deferens *(ampulla ductus deferentis)*.

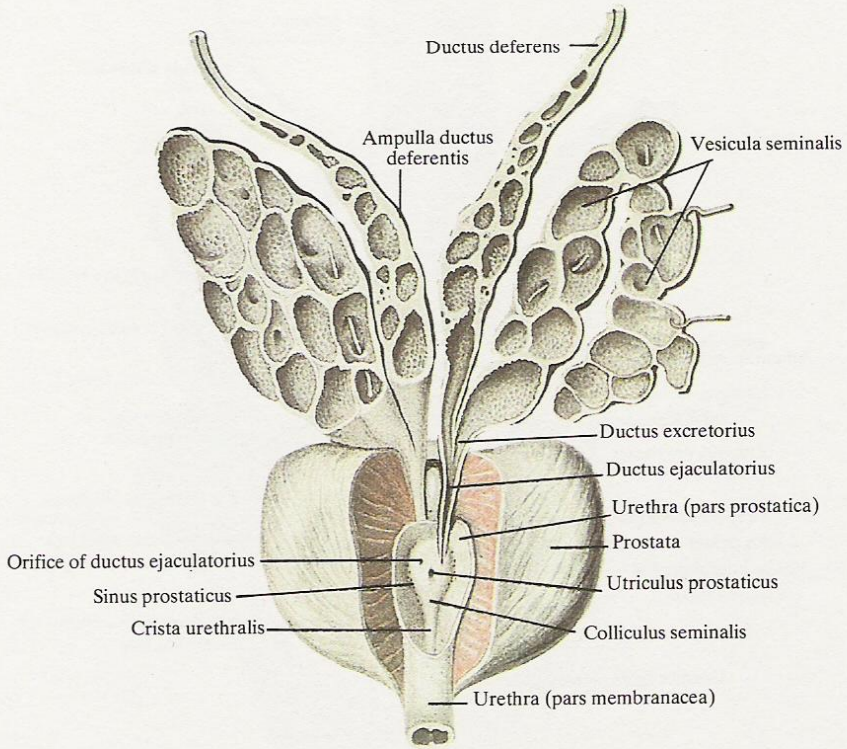
At the base of the prostate the duct of the vesicle merges with the distal end of the ampulla to form a common **ejaculatory duct** *(ductus ejaculatorius)* which passes through the body of the prostate and opens slit-like on the surface of the mucous coat of the prostatic part of the urethra, lateral to the seminal colliculus *(colliculus seminalis)*.

Innervation: the hypogastric and pelvic plexuses (*plexus hypogastrici superior* et *inferior*).

Blood supply: the superior and middle rectal, inferior vesical arteries, and the artery of the vas deferens (*arteriae rectales superior* et *media, vesicalis inferior, ductus deferentis*).

THE PROSTATE

The **prostate** *(prostata)* (Figs 547–549, 555, 556) is an unpaired organ of glandular and muscular (smooth) tissue. It is situated in the lower part of the cavity of the true pelvis under the urinary bladder, and between the bladder, the anterior wall of the rectum, and the anterior part of the urogenital diaphragm. The gland embraces the beginning of the urethra, its prostatic part *(pars prostatica)*, and the ejaculatory ducts. The prostate resembles a chestnut in shape and has a narrower part called the **apex** *(apex prostatae)* which is directed downwards at the urogenital diaphragm, and a wide concave part directed at the urinary bladder which is called the **base** *(basis prostatae)*. The **anterior surface of the prostate** *(facies anterior prostatae)* faces the pubic symphysis, the **posterior surface of the prostate** *(facies posterior prostatae)* faces the ampulla of the rectum. The rounded **inferolateral surfaces** *(facies inferolaterales)*



556. *Prostate (prostata) and seminal vesicles (vesiculae seminales);* anterior aspect (1/1).

[The seminal vesicles and the ampulla of vas deferens *(ampulla ductus deferentis)* are opened; the anterior parts of the prostate are partly removed; the prostatic part of the urethra is opened.]

are also distinguished in the prostate, which are directed to the right and left sides, to the levator ani muscles respectively.

The prostate is made up of the **right** and **left lobes** (*lobus dexter* et *lobus sinister*) which are separated along the posterior surface of the gland by an indistinct groove and the **isthmus of the prostate** *(isthmus prostatae)*, or the median lobe *(lobus medius)*.

The isthmus of the prostate is an area bounded anteriorly by the place of entry of the neck of the bladder into the base of the gland and posteriorly by the site of entry of the right and left ejaculatory ducts. At elderly age the isthmus grows considerably in size and in such instances is known as the **median lobe of the prostate** *(lobus medius prostatae)* (Fig. 555).

The urethra passes through the anteroinferior part of the gland, piercing its apex in such a manner that the greater part of the prostate is under the urethra and the lesser part is above it. The ejaculatory ducts run downwards and from back to front through the base of the gland.

The prostate has a transverse diameter of about 4 cm, a vertical diameter of 3 cm, and an anteroposterior diameter of 2 cm; it weighs 20 g on the average. The size and weight of the prostate change with age: it is small in children but may reach the size of an egg in the elderly. It develops completely by the age of 17.

The prostate is made up of **glandular substance** *(substantia glandularis)* and **muscular tissue** *(substantia muscularis)*.

The glandular substance, however, is irregularly arranged in the organ: it prevails over the connective tissue in the direction of the rectum but is developed less than the muscular tissue in the direction of the urethra.

The glandular substance surrounds the prostatic part of the urethra and consists of 30 to 50 branching tubuloacinar **prostatic ducts** *(ductuli prostatici)* which are lined with a double-layer cuboidal epithelium.

The bulk of prostatic ducts and the longest of them are found in the posterior and lateral parts of the gland, while only a few, and the shortest ducts are in the anterior part; the median, closest to the front area is devoid of the ducts and contains muscular tissue only.

The gland is invested in a capsule from which connective-tis-

sue elastic fibres and smooth muscles arise and penetrate the gland forming its stroma. The stroma lies between the ducts and separates the glandular substance into lobules.

Muscle fibres pass into the gland from the wall of the urinary bladder which is related to its base. The apex of the gland, which is lodged in the urogenital diaphragm, contains striated muscle fibres running into it from the diaphragm and forming part of the voluntary **sphincter urethrae muscle** *(musculus sphincter urethrae)*. The orifices of the prostatic ducts, about 30 in number, open on the surface of the mucous coat of the prostatic part of the urethra, on the seminal colliculus and around it.

The anterior surface of the gland is formed by its smallest portion situated in front of the urethra; it faces the pubic symphysis. The **puboprostatic** (or **pubovesical**) **ligaments** (*ligamenta puboprostatica* s. *pubovesicalia*) stretch from the pubic symphysis and related part of the tendinous arch to the anterior and lateral surfaces of the gland.

The anterior surface of the base of the gland comes in contact with the lower part of the bladder; the posterior surface is related to the bodies of the seminal vesicles laterally and the ampullae of the vasa deferentia medially.

The posterior surface of the prostate is in relation with the septum separating it from the ampulla of the rectum and forming the posterior wall of its capsule.

The inferolateral surfaces of the gland, which are separated by the wall of the capsule, are in contact with the medial borders of both levator ani muscles whose contraction may raise the prostate. Under the capsule of the gland pass veins belonging to the venous plexus into which the deep dorsal vein of the penis drains in front (Fig. 561).

The isthmus of the prostate *(isthmus prostatae)* is related to the posterior wall of the urethra and contains the prostatic utricle *(utriculus prostaticus)* which is lodged in the seminal colliculus of the urethra. The utricle is shaped like an elongated pouch measuring up to 1 cm in length and 1–2 mm in width.

Innervation: the hypogastric plexus *(plexus hypogastricus)*.

Blood supply: the middle rectal and inferior vesical arteries (*arteriae rectalis media* et *vesicalis inferior*).

THE BULBO-URETHRAL GLANDS

The two **bulbo-urethral glands** *(glandulae bulbo-urethrales)* (Figs 549, 557) are pea-shaped yellowish-brown bodies situated behind the membranous part of the urethra at the blind end of the bulb of the penis. They are embraced by the bundles of the deep transverse perinei muscle *(musculus transversus perinei profundus)*.

The separate lobules of the gland are joined by dense connective tissue. The ducts of each lobule fuse to form the common **duct of the bulbo-urethral gland** *(ductus glandulae bulbourethralis)* which is surrounded by the fibres of the sphincter urethrae muscle *(musculus sphincter urethrae)*.

The duct of the gland measures up to 6 cm in length. It passes anteriorly and slightly downwards, pierces the bulb of the penis, and opens into the cavity of the urethra. Sometimes the right and left glands are joined to one another by fine muscular bundles. Accessory glands are encountered in some cases.

Innervation: the hypogastric plexus *(plexus hypogastricus)*.

Blood supply: the artery of the bulb of the penis *(arteria bulbi penis)* which arises from the internal pudendal artery *(arteria pudenda interna)*.

THE EXTERNAL MALE GENITAL ORGANS

THE PENIS

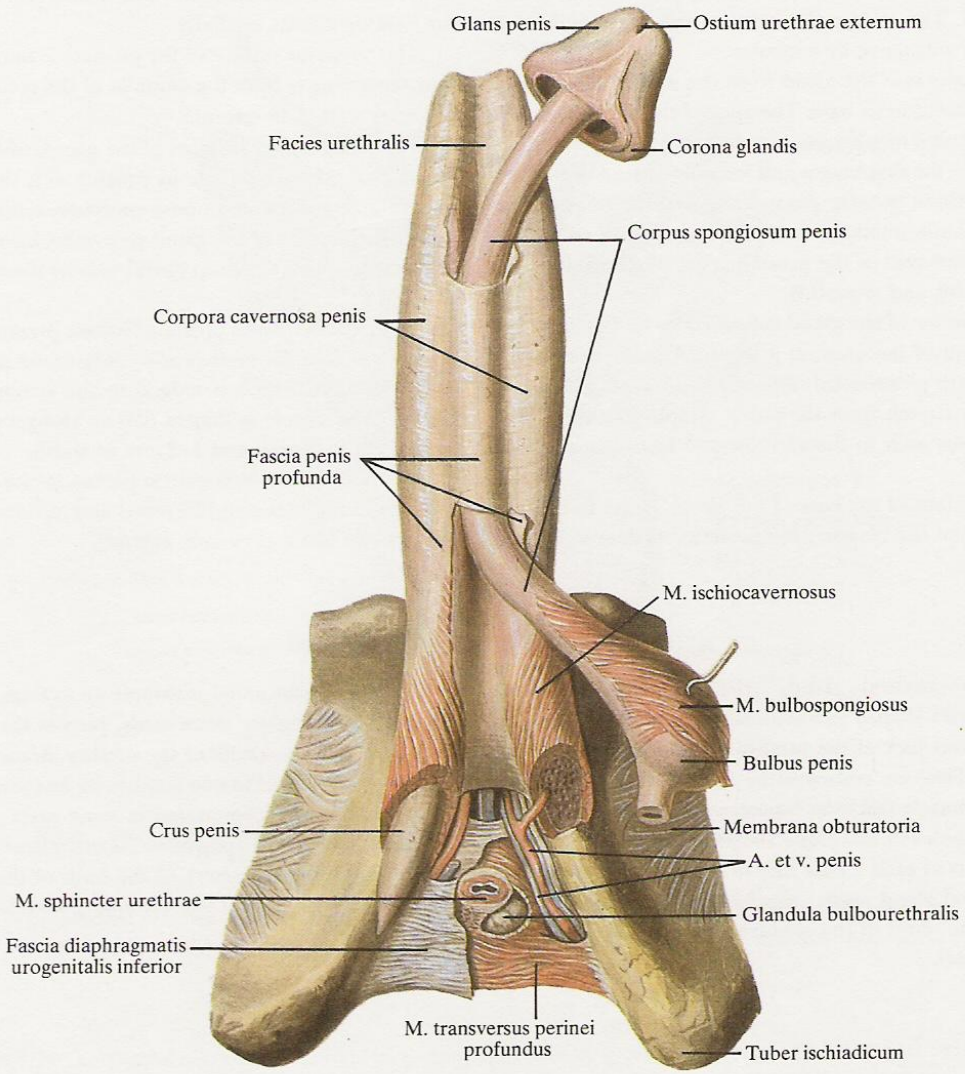
The **penis** (Figs 547–549, 557–561) is for the most part formed of erectile tissue which is arranged in the form of three bodies: a paired **corpus cavernosum penis** and an unpaired **corpus spongiosum penis**. The posterior part of the penis has an immobile area which is covered by the skin of the scrotum and attached to the anterior surface of the pubis; this is the **root of the penis** *(radix penis)*. The **body of the penis** *(corpus penis)* and the **glans penis** are distinguished.

The body of the penis has an upper (anterior) surface which is called the **dorsum of the penis** *(dorsum penis)*, and a lower (posterior) surface known as the **urethral surface** *(facies urethralis)*.

The glans is the free end of the penis. It is shaped like a cone slightly flattened at the top and bottom. Its lower surface is also flattened. The posterior, rising margin of the glans is thickened to form the **corona glandis** which is separated from the body by a shallow groove called the **neck of the penis** *(collum glandis)*.

The **external orifice of the urethra** *(ostium urethrae externum)* opens on the tip of the glans (Fig. 549).

The skin of the penis, being a continuation of the skin of the pubic elevation and scrotum, is thin and stretchable; it is separated from the underlying fascia by loose areolar tissue and is consequently easily movable. The skin on the glans penis is also thin but intimately fused with the underlying tunica albuginea of the corpora cavernosa and is therefore immobile. In the region of the neck of the penis the skin forms a fold which overlaps the glans to a variable extent. This fold is called the **prepuce** *(preputium)*. A preputial sac open to the front thus forms between the glans and the prepuce. The prepuce, therefore, has two skin surfaces: an inner,



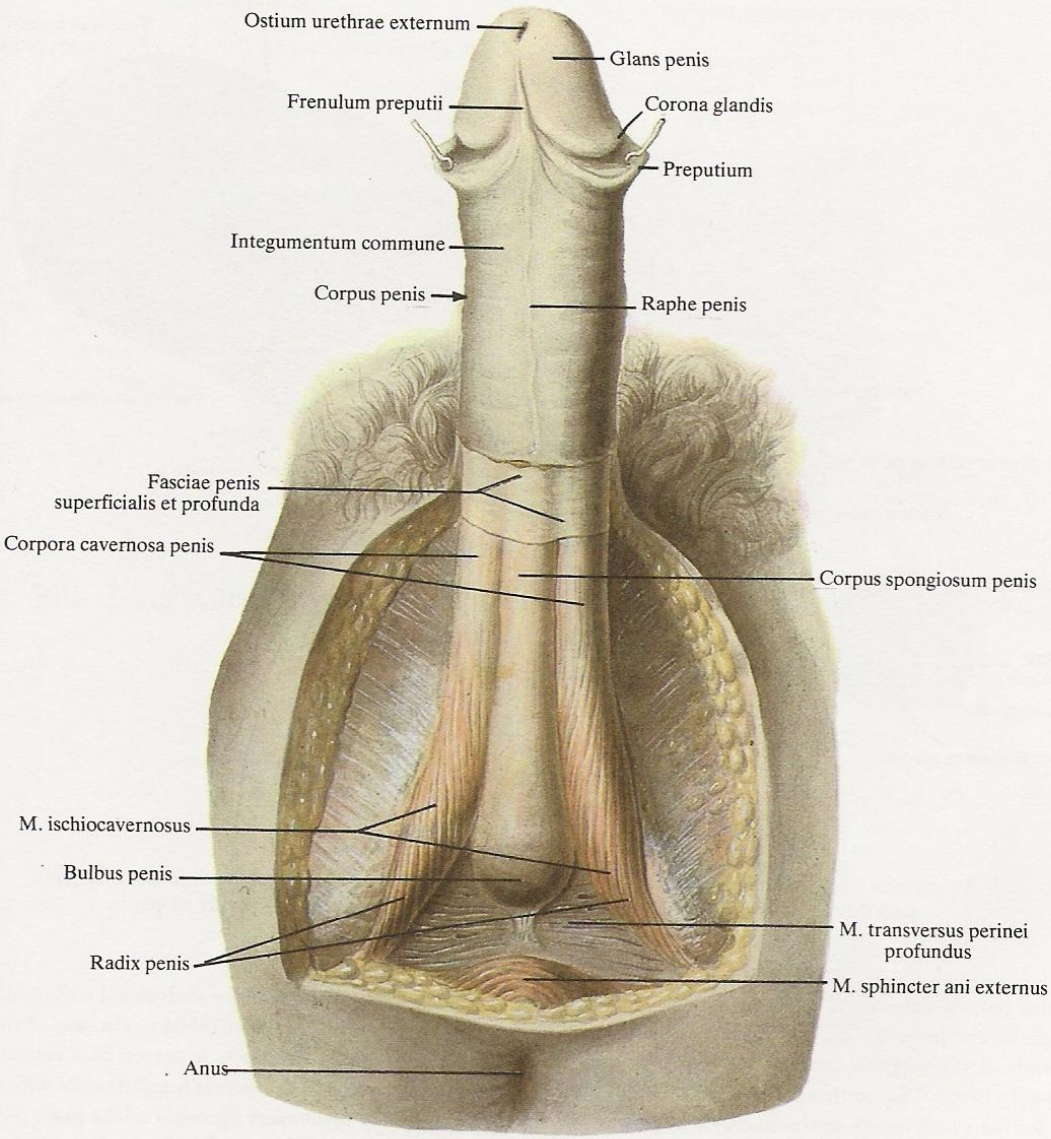
557. *Corpora cavernosa and corpus spongiosum penis;* anteroinferior aspect (¾).

(Corpus spongiosum with urethra is partly separated from corpora cavernosa penis.)

more delicate, facing the glans, and an outer, thicker skin. On the lower surface of the glans the prepuce forms a longitudinal fold called the **frenulum of the prepuse** *(frenulum preputii)* by means of which the skin is joined to the contralateral surface of the preputial sac.

The **corpora cavernosa penis** are almost cylindrical structures with pointed anterior and posterior ends. Each corpus cavernosum arises by its posterior end, called the **crus of the penis** *(crus penis)*, from the periosteum of the medial border of the inferior pubic ramus and the ramus of the ischium in the region of the subpubic angle *(angulus subpubicus)*. The medial surfaces of both corpora cavernosa fuse anteriorly. Their inferior surface bears the urethral groove in which the corpus spongiosum is lodged and attached to it by dense connective tissue. The superior surface of the corpora cavernosa carries a groove transmitting the dorsal vessels and nerves. The glans is fitted to the anterior ends of the corpora cavernosa like a cap.

Each corpus cavernosum is enclosed in a dense 2-mm thick connective-tissue capsule called the **tunica albuginea corporis cavernosi** which gives off into it **trabeculae of the corpora cavernosa**



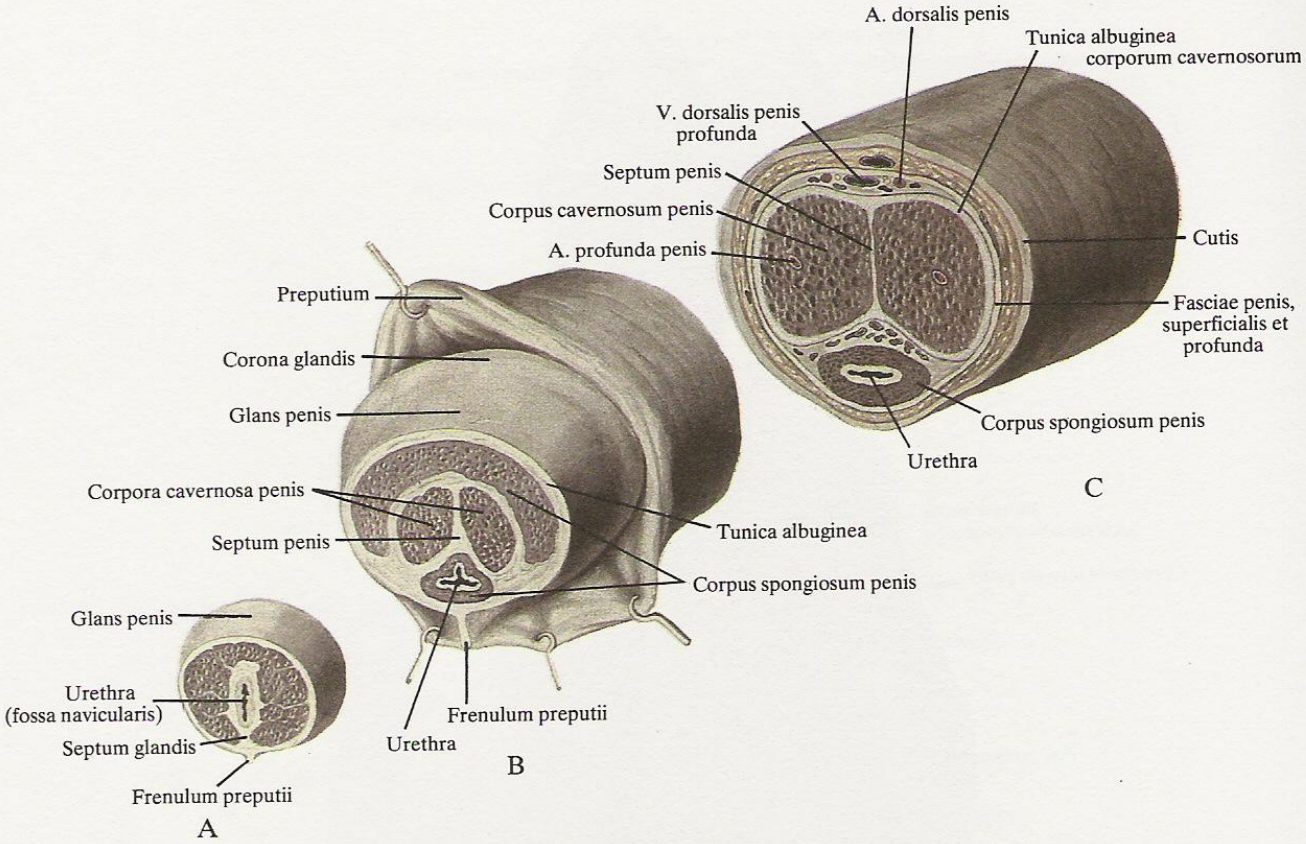
558. *Penis;* inferoanterior aspect (¾).
(The skin and fascia of the penis are partly removed.)

(trabeculae corporis cavernosi); the trabeculae isolate spaces filled with venous blood in the corpus cavernosum, which are known as **venous spaces of the corpora cavernosa** *(cavernae corporis cavernosi)*. Where the right and left corpora cavernosa meet, the tunica albuginea sends off the median **septum of the penis** *(septum penis)* which separates them. The septum has openings through which the vessels of the corpora cavernosa communicate.

The deep artery of the penis *(arteria profunda penis)* passes in the centre of each corpus cavernosum. The blood from the corpora cavernosa drains into the unpaired deep dorsal vein of the penis *(vena dorsalis penis profunda)* which lies on the dorsum of the penis between the two dorsal arteries of the penis *(arteriae dorsales penis)*.

The **corpus spongiosum penis** is much smaller in bulk than the corpora cavernosa and is flattened anteroposteriorly; its posterior end is thickened to form the **bulb of the penis** *(bulbus penis)*.

The bulb is related to the urogenital diaphragm. Its two halves are distinctly outlined because they are adjoined laterally by the ischiocavernosus muscles *(musculi ischiocavernosi)* and covered by the bulbospongiosus muscles *(musculi bulbospongiosi)*.



559. *Transverse sections of penis* (3/2).

A—section through glans near the external orifice of urethra; B—section through glans in the middle of the fossa terminalis; C—section through middle parts of body of penis.

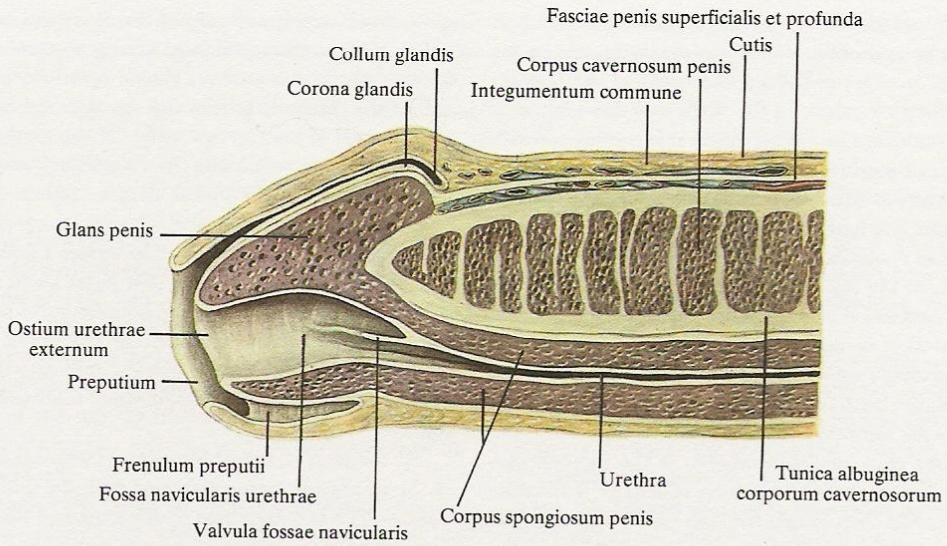
The anterior part of the corpus spongiosum penis is continuous with the glans; the posterior surface has a depression lodging the anterior ends of the corpora cavernosa penis with which the glans is intimately fused. The urethra enters the bulb from above and stretches for the whole length of the corpus spongiosum to the tip of the glans on which it opens by the external orifice of the urethra *(ostium urethrae externum)*. The corpus spongiosum is invested in a thin tunica albuginea. The tunica albuginea of the glans gives rise to the **septum of the glans** *(septum glandis)* which stretches on the midline to the wall of the urethra.

The tunica albuginea of the corpus spongiosum is covered by the **superficial fascia of the penis** *(fascia penis superficialis)* which is a continuation of the fascia of the perineum *(fascia perinei)*, the superficial fascia of the anterior abdominal wall, and the dartos muscle of the scrotum, and is attached to the skin of the penis by loose connective tissue. The glans is devoid of a subcutaneous connective-tissue layer and the skin is fused directly with the tunica albuginea. A short **suspensory ligament of the penis** *(ligamentum suspensorium penis)* (Fig. 547) stretches from the anterior surface of the pubic symphysis to the dorsum of the penis. It is formed of thick elastic fibres arising from the superficial abdominal fascia, and is interlaced with the tunica albuginea. Another ligament, the **fundiform ligament of the penis** *(ligamentum fundiforme penis)*, runs downwards from the linea alba and embraces the penis on the sides. Its fibres enter the scrotum and interlace with the dartos muscle.

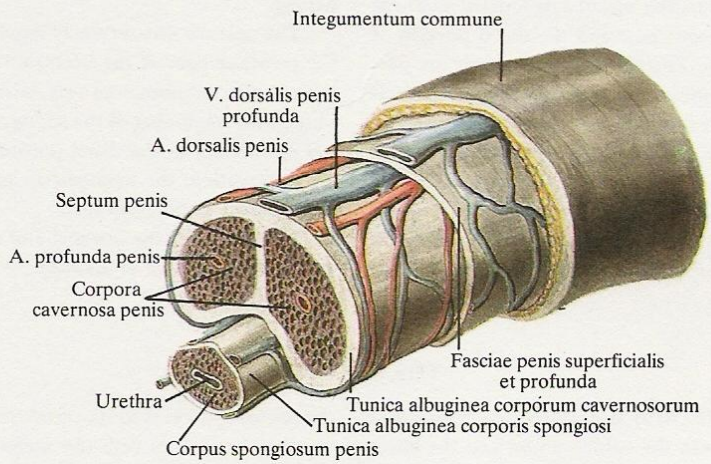
THE MALE URETHRA

The **male urethra** *(urethra masculina)* (Figs 548, 549, 560) is a canal measuring 20 to 23 cm in length on the average. It is divided into three parts: prostatic part *(pars prostatica)*, membranous part *(pars membranacea)*, and spongy part *(pars spongiosa)*. It begins from the urinary bladder by the **internal urethral orifice** *(ostium urethrae internum)* and stretches to the **external urethral orifice** *(ostium urethrae externum)* on the tip of the glans.

The part of the urethra between the internal orifice and the



560. *Longitudinal section through anterior parts of penis, right side;* from left side (3/2).



561. *Corpora cavernosa and corpus spongiosum penis* (4/3).

seminal colliculus *(colliculus seminalis)* is called the posterior urethra, the distal part is the anterior urethra.

The urethra describes an S-shaped course: the first, prostatic, part together with the membranous and the distal portion of the spongy part forms a posteriorly convex arch which bends round the pubic symphysis inferiorly to form the subpubic curvature. The proximal portion of the spongy part, passing through the part of the penis which is fastened by ligaments, forms with the flaccid part of the penis a second curvature which is convex anteriorly—this is the prepubic curvature.

The urethra is divided into the three parts because of the specific features of the structures surrounding it.

The **prostatic part** *(pars prostatica)* pierces the prostate from above, from the back downwards, and forwards. It is 3–4 cm in length and begins by its narrow part from the internal urethral orifice (the first narrow portion of the channel). A dilatation of the

urethra forms in the middle of its course (the first dilatation). A median fold called the **urethral crest** *(crista urethralis)* passes on the posterior wall of the mucous coat from the uvula of the bladder which is a longitudinal elevation on the surface of the trigone of the bladder. In the middle of its course the crest is continuous with a longitudinally placed **seminal colliculus** *(colliculus seminalis)*; distally the crest stretches to the membranous part. On the apex of the seminal colliculus is a longitudinal pouch known as the **prostatic utricle** *(utriculus prostaticus)*. On either side of the urethral crest are the orifices of the ejaculatory ducts. To both sides of the seminal colliculus, between it and the wall of the urethra, the mucous coat of the urethra forms folds. The groove between these folds is called the **prostatic sinus** *(sinus prostaticus)* and contains the orifices of the prostatic ducts *(ductuli prostatici)*; some of the ducts sometimes open on the seminal colliculus itself.

The **membranous part** *(pars membranacea)* is the shortest portion of the urethra and measures 1.5–2.0 cm in length. It is firmly attached to the urogenital diaphragm through which it passes. The proximal segment of this part is the narrowest portion of the urethra (the second narrow portion); the distal segment passing into the spongy part becomes wider.

The internal orifice of the urethra and the proximal segment of the prostatic part are encompassed by smooth muscle fibres forming the internal urethral sphincter; these fibres are a continuation of the muscles of the trigone of the bladder and interlace with the muscular tissue of the prostate. The striated sphincter urethrae muscle surrounds the membranous part and the distal portion of the prostatic part of the urethra. The fibres of this muscle are part of the deep transverse perinei muscle, due to which the membranous part is held fast at the exit from the pelvis, its mobility being still less because part of the fibres of the urogenital diaphragm pass to both the prostatic and spongy parts of the urethra.

The **spongy part** *(pars spongiosa)* is the longest portion of the urethra and measures 17–20 cm in length. It begins from the widest portion of the urethra (the second dilataion) lodged in the bulb of the penis, reaches the tip of the glans and ends at the external orifice of the urethra (the third narrow portion of the urethra). The ducts of the bulbo-urethral glands open on the posterior (lower) wall of the proximal part of the spongy urethra.

Proximal to the external orifice of the urethra is a sagittal dilatation, the **fossa terminalis** *(fossa navicularis urethrae)*, which is the third dilatation in the course of the urethra. The mucous membrane forms on the upper wall of the fossa a transverse **valvula fossae navicularis** (Fig. 560), which separates a pouch open anteriorly. The upper wall of the spongy part bears small transverse folds arranged in two rows forming the boundaries of small (0.5 mm) **lacunae urethrales** which are open to the front; the tubulo-acinar **urethral glands** *(glandulae urethrales)* open into them (Fig. 549). The walls of the channel form longitudinal folds which make it stretchable.

At the level of the prostatic and membranous parts the lumen of the urethra is crescent-shaped with the concavity directed upwards, which is determined by the crest and the seminal colliculus. The lumen of the spongy urethra is shaped like a vertical slit in the proximal portion, a transverse slit in the distal portion, and an S-like slit in the region of the glans.

The capsule of the urethra is composed of elastic fibres.

Only the prostatic and membranous parts have a pronounced muscular layer; in the spongy part the mucous membrane is fused with the erectile tissue to which its smooth muscular fibres belong.

The mucous membrane is lined with transitional epithelium in the prostatic part of the urethra, with stratified columnar epithelium in the membranous part, with single-layer columnar epithelium at the beginning of the spongy part, and with stratified columnar epithelium in the distal portion.

Innervation: the hypogastric and lumbosacral plexuses (*plexus hypogastricus* et *lumbosacralis*).

Blood supply: the internal and external pudendal arteries (*arteriae pudendae interna* et *externa*).

THE SCROTUM

The **scrotum** (Figs 547, 548, 575) is a structure of skin and muscles containing the testes with the epididymides and the lower portion of the spermatic cords. It occupies the anterior part of the perineal region behind the penis; it consists of a skin covering and several layers of capsules.

The skin of the scrotum is a direct continuation of the skin of the penis; it is thin, devoid of fat, wrinkled, darker than the skin of the abdomen and thighs, and covered sparsely with hairs. Many sweat and sebaceous glands are embedded in the skin. The **raphe of the scrotum** *(raphe scroti)* is a ridge of skin running in the antero-posterior direction on the midline from the root of the penis to the perineum. Under the skin is the **dartos muscle** *(tunica dartos)* composed of a network of smooth muscle fibres. It is fused with the skin by a very great number of trabeculae. Contraction of this muscle gathers the skin of the scrotum into numerous folds. Under the dartos muscle is loose connective tissue devoid of fat and connecting the muscle with the underlying **external spermatic fascia** *(fascia spermatica externa)* which is a continuation of the intercrural fibres of the aponeurosis of the external oblique muscle of the abdomen, and covering both the **cremaster muscle** *(musculus cremaster)* and the **cremaster fascia** *(fascia cremasterica)*.

The next layers, which are described above and related to the scrotum as the receptacle of the testes, are as follows: the **internal spermatic fascia** *(fascia spermatica interna)*, next comes the **tunica vaginalis testis** in which a **parietal layer** *(lamina parietalis)* and a **visceral layer** *(lamina visceralis)* are distinguished, and, finally, the **tunica albuginea of the testis** *(tunica albuginea testis)*.

The cavity of the scrotum is divided into a right and left halves by a sagittal **septum of the scrotum** *(septum scroti)* which corresponds to the raphe of the scrotum on the skin surface (Fig. 548).

Innervation: the hypogastric plexus, the pudendal, ilio-inguinal, genitofemoral nerves *(plexus hypogastricus, nervi pudendi, ilioinguinales, genitofemorales)*.

Blood supply: scrotal branches of the external and internal pudendal arteries (femoral and obturatory arteries) [*rami scrotales anteriores* et *posteriores (arteriae femoralis, pudenda interna, obturatoria)*].

THE PERITONEUM OF THE CAVITY OF THE MALE TRUE PELVIS

On descending from the cavity of the abdomen on the posterior wall, the parietal peritoneum in the cavity of the male true pelvis passes over the arcuate line *(linea terminalis)* (Figs 547, 570, 571) and covers mesoperitoneally the anterior surface of the middle third of the rectum. It then passes onto the upper border of the seminal vesicles and the vasa deferentia, ascends to cover the posterior surface of the urinary bladder, leaves the cavity of the true pelvis, and is continuous with the parietal peritoneum of the anterior abdominal wall.

A frontally situated slit called the **rectovesical pouch** *(excavatio rectovesicalis)* forms between the rectum and bladder; it may become deeper when the bladder is filled. The pouch is bordered by the rectovesical (sacrogenital) folds in which the **rectovesical muscles** *(musculi rectovesicales)* are embedded; these contain smooth muscle fibres.

When the bladder is empty, the peritoneum forms symmetrical folds along its margins slightly in front of the apex which are directed towards the **median umbilical fold** *(plica umbilicalis mediana)*; these are known as the pubovesical folds. On the posterior surface of the bladder, closer to the apex, is still another peritoneal fold called the **transverse vesical fold** *(plica vesicalis transversa)* which stretches between the deep inguinal rings.

THE FEMALE GENITAL ORGANS

Internal and external female genital organs are distinguished. The **internal female genital organs** *(organa genitalia feminina interna)* are: the ovary *(ovarium)*, the uterine tube (*tuba* s. *salpinx uterina*), the uterus (*uterus* s. *metra*), the vagina, and the epoöphoron. The **external female genital organs** *(organa genitalia feminina externa)* are as follows: the pudendum muliebre *(pudendum femininum)*, the clitoris, and the female urethra *(urethra feminina)*.

THE INTERNAL FEMALE GENITAL ORGANS

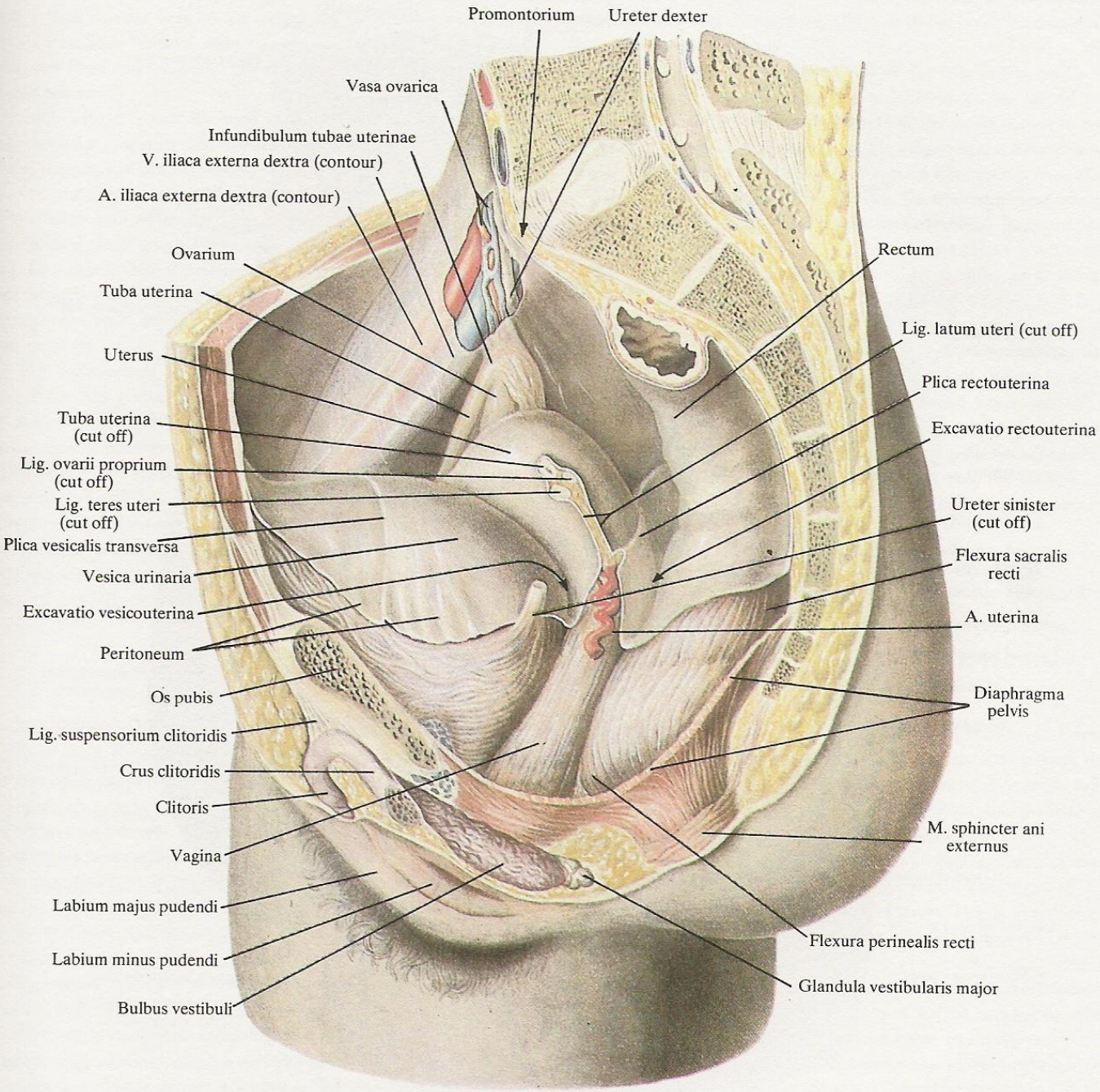
THE OVARIES

The **ovary** *(ovarium)* (Figs 562–565, 572) is a paired organ, the female gonad, in which the ova are formed and mature. Each ovary is situated transversely on the lateral wall of the true pelvis, to the side of the fundus of the uterus where it is attached by the mesentery to the posterior layer of the broad ligament of the uterus below the uterine tube (see Vol. III, *The Reproductive Glands*).

The ovary is bluish-white in colour, its surface is slightly uneven, and it has a flattened oval shape. It has two surfaces—**medial** *(facies medialis)* and **lateral** *(facies lateralis)*; two borders—a straight **mesovarian border** *(margo mesovaricus)* and a convex **free border** *(margo liber)*; two ends—the **tubal end** *(extremitas tubaria)* facing the fimbriae of the tube and the **uterine end** *(extremitas uterina)* which is sharper and faces the uterus. The ovary of a mature female measures 2.5–5.0 cm in length, 1.5–3.0 cm in breadth, and 0.5–1.5 cm in thickness. Its weight varies from 5 to 8 g. Both the size and the weight of the ovaries vary greatly and depend on the age, the individual features, and the general condition of the organism.

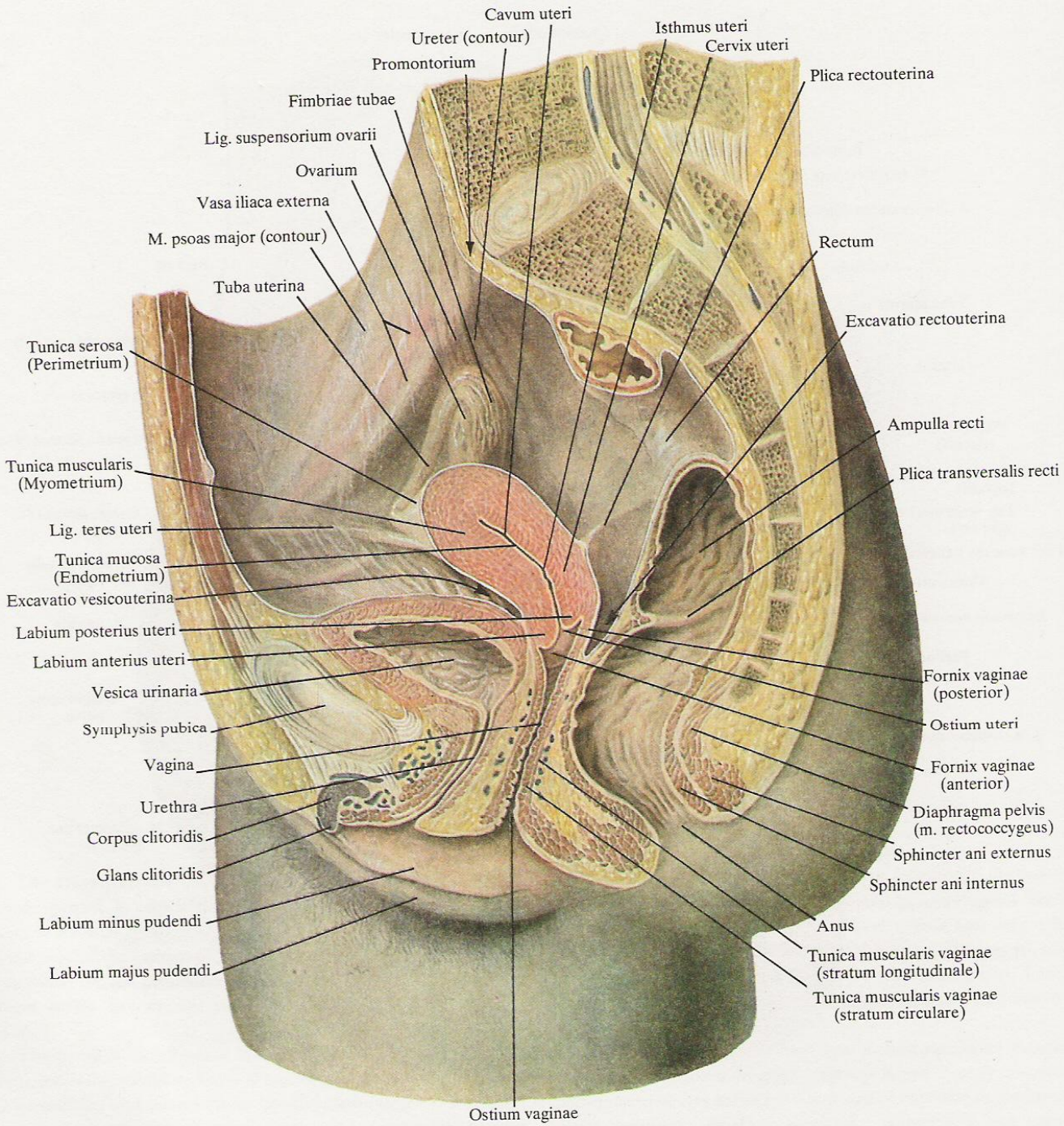
The mesovarian border of the ovary is attached to the posterior layer of the broad ligament of the uterus by a peritoneal duplicature called the **mesovarium** transmitting vessels and nerves from the broad ligament into the **hilum of the ovary** *(hilus ovarii)*, which is a narrow groove to which the mesovarium is attached. The free border of the ovary is convex and suspended freely into the cavity of the pelvis.

Microscopically the ovary has a heterogeneous structure; though it is an intraperitoneal organ it is not directly covered by peritoneum; its free surface is composed of cuboidal single-layer inactive germinal epithelium lying on a connective-tissue capsule. Within the capsule, the ovary is composed of superficial dense **cortical substance** *(cortex ovarii)*, glandular tissue, a centrally situated **medullary substance** *(medulla ovarii)* rich in vessels and loose connective tissue, which forms the **stroma of the ovary** *(stroma ovarii)*. In the region of the hilum the cortical substance comes to naught. The degree of the development of the cortical and medullary substance is determined by the age of the individual.



562. *Female genital organs (organa genitalia feminina)* (⅔).

(Left parts of the walls of the pelvis are removed.)



563. *Female genital organs (organa genitalia feminina)* (⅔).
(Midsagittal section; right side.)

The cortical substance contains many large (to the size of a pea) vesicular spherical sacs going through various developmental stages. The smaller vesicles are called the primordial, or **primary ovarian follicles** *(folliculi ovarici primarii)*, the larger ones contain follicular fluid and are called the **vesicular ovarian follicles** *(folliculi ovarici vesiculosi)*.

Each follicle is a cavity lined with cells and enclosed in a connective-tissue capsule; the female reproductive cell called the **ovum** develops in the follicle.

On maturation the follicle grows larger, moves to the surface of the ovary and protrudes from it slightly. The wall of a mature follicle is a thick connective-tissue capsule called the **theca folliculi**. In a ripe follicle it ruptures, and the ovum released by the follicle is guided by the ovarian fimbria *(fimbria ovarica)* through the uterine tube *(tuba uterina)* into the cavity of the uterus (the ovulation process).

The follicle may fail to complete its development, in which case it resolves gradually.

An endocrine gland, called the **corpus luteum of menstruation** *(corpus luteum menstruationis)* (Fig. 565) forms in place of the ruptured follicle and later atrophies and transforms into a connective-tissue **corpus albicans** which disappears subsequently. If the ovum is impregnated the corpus luteum persists to the end of pregnancy and is called in this case the corpus luteum of pregnancy *(corpus luteum graviditatis)* in distinction from the disappearing corpus luteum of menstruation.

The **stroma of the ovary** *(stroma ovarii)* consists of connective tissue with a large admixture of elastic fibres. It is rich in blood vessels which enter through the hilum of the ovary. It also contains lymph vessels and nerves.

The ovary lies on the lateral wall of the true pelvis and is encased superiorly, laterally, and partly medially by the lateral portion of the uterine tube. The tubal end of the ovary comes in contact with the parietal peritoneum and is lodged in the ovarian fossa which is bordered superiorly by the external iliac vessels *(vasa iliaca externa)*, posteriorly by the internal iliac vessels *(vasa iliaca interna)* and the ureter, anteriorly by the lateral umbilical ligament, and inferiorly by the obturator and uterine arteries (*arteriae obturatoria* et *uterina*). The medial surface of the ovary is directed at the abdominal cavity of the true pelvis. The tubal end of the ovary faces the ovarian fimbria *(fimbria ovarica)* of the uterine tube and is held fast by the **infundibulopelvic ligament** *(ligamentum suspensorium ovarii)* which stretches to the fascia psoatica and the psoas major muscle. As a result the ovary is fastened to the lateral surface of the pelvis. The ligament contains vessels and nerves of the ovary. The **ligament of the ovary** *(ligamentum ovarii proprium)* (Fig. 565) stretches in the broad ligament of the uterus from the uterine end of the ovary to the border of the uterus on which it terminates below the uterine tube.

Innervation and blood supply of the ovaries: see *The Uterus*.

THE UTERINE TUBES

The **uterine tube** *(tuba uterina)* (Figs 564, 565, 572) is a paired organ situated almost horizontally on either side of the fundus of the uterus in the free (upper) border of the broad ligament of the uterus. Each tube is a cylindrical canal with one (lateral) end opening into the cavity of the abdomen and the other (medial) end opening into the cavity of the uterus. The tube of an adult female measures 10–12 cm in length on average and 0.5 cm in width. The right and left tubes differ in length.

Several parts are distinguished in the uterine tube: the infundibulum *(infundibulum tubae uterinae)*, a dilatation called the ampulla *(ampulla tubae uterinae)*, the isthmus *(isthmus tubae uterinae)*, and the uterine (interstitial) part *(pars uterina)*.

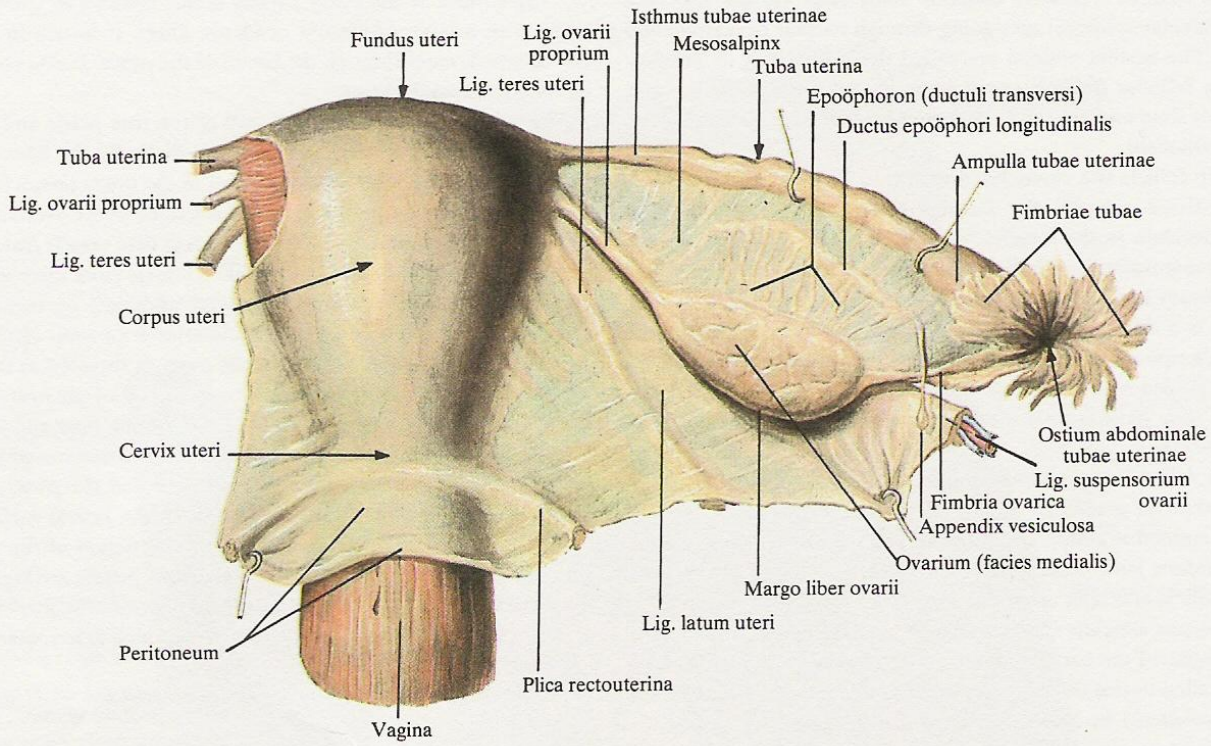
The lateral end is the **infundibulum of the uterine tube** *(infundibulum tubae uterinae)* which bears the **pelvic opening of the uterine tube** *(ostium abdominale tubae uterinae)* bordered by a great number of pointed processes called the **fimbriae of the uterine tube** *(fimbriae tubae)*. Each fimbria has small notches on its ends. The longest is the **ovarian fimbria** *(fimbria ovarica)* which passes on the lateral margin of the mesosalpinx and has the appearance of a groove running to the tubal end of the ovary to which it is attached. The free abdominal (medial) end of the tube sometimes carries a small vesicular appendage suspended freely on a long peduncle.

The pelvic opening of the tube measures up to 2 mm in diameter; it connects the cavity of the abdomen with the external environment via the uterine tube, uterus, and vagina. The lateral, distended part is called the **ampulla of the uterine tube** *(ampulla tubae uterinae)* and is its longest portion; it is tortuous, has a wider lumen, and is up to 8 mm thick.

The medial part of the uterine tube is straighter and narrower. Its isthmus *(isthmus tubae uterinae)* approaches the angle of the uterus at the junction of its fundus and body. This is the thinnest segment of the tube (about 3 mm thick) and its lumen is very narrow. It is continuous with the segment of the tube embedded in the wall of the uterus, the **uterine part** *(pars uterina tubae uterinae)*, which opens into the cavity of the uterus by the **uterine opening** *(ostium uterinum tubae)* measuring up to 1 mm in diameter.

The **serous coat** *(tunica serosa)* invests the uterine tube on the sides and above and makes up the superolateral surfaces of the broad ligament of the uterus. The part of the uterine tube directed into the broad ligament is free of peritoneum. The anterior and posterior layers of the ligament fuse here to form the ligament between the tube and the ovary, which is called the **mesosalpinx**.

Under the serous coat is loose connective tissue of the type of adventitium, the **subserous coat of the uterine tube** *(tunica subserosa tubae uterinae)*. Still deeper is the **muscular coat** *(tunica muscularis)*. It consists of smooth muscle fibres arranged in three layers: a thin outer longitudinal (subperitoneal) layer, a thicker middle circular



564. *Uterus, uterine tube (tuba uterina), ovary (ovarium), and part of vagina;* posterior aspect (⅘).

layer, and an inner longitudinal (submucous) layer whose fibres are developed best in the region of the isthmus and uterine part of the tube. The muscular coat of the uterine tube is developed more in the medial and uterine parts and reduces gradually towards the lateral (ovarian) end.

The muscular coat envelopes the innermost layer of the wall of the uterine tube—the **mucous coat** *(tunica mucosa)* which forms characteristic longitudinal **plicae tubariae**. In the ampulla the folds are distinctly outlined: they are high and form secondary and tertiary folds. In the isthmus the folds are developed less: they are lower and have no secondary folds. In the intra-uterine (interstitial) part the folds are very poorly developed.

Along the margins of the fimbriae the mucous coat of the uterine tube borders upon the peritoneum. The mucous membrane is formed by single-layer columnar ciliated epithelium whose cilia beat towards the uterine end of the tube. Some of the epithelial cells are devoid of cilia and contain secretory elements.

The isthmus of the uterine tube forms a right angle with the uterus and lies almost horizontally; the ampulla of the tube arches over the lateral surface of the ovary; the medial end of the tube passes on the medial surface of the ovary and reaches the level of the horizontally stretching part of the isthmus.

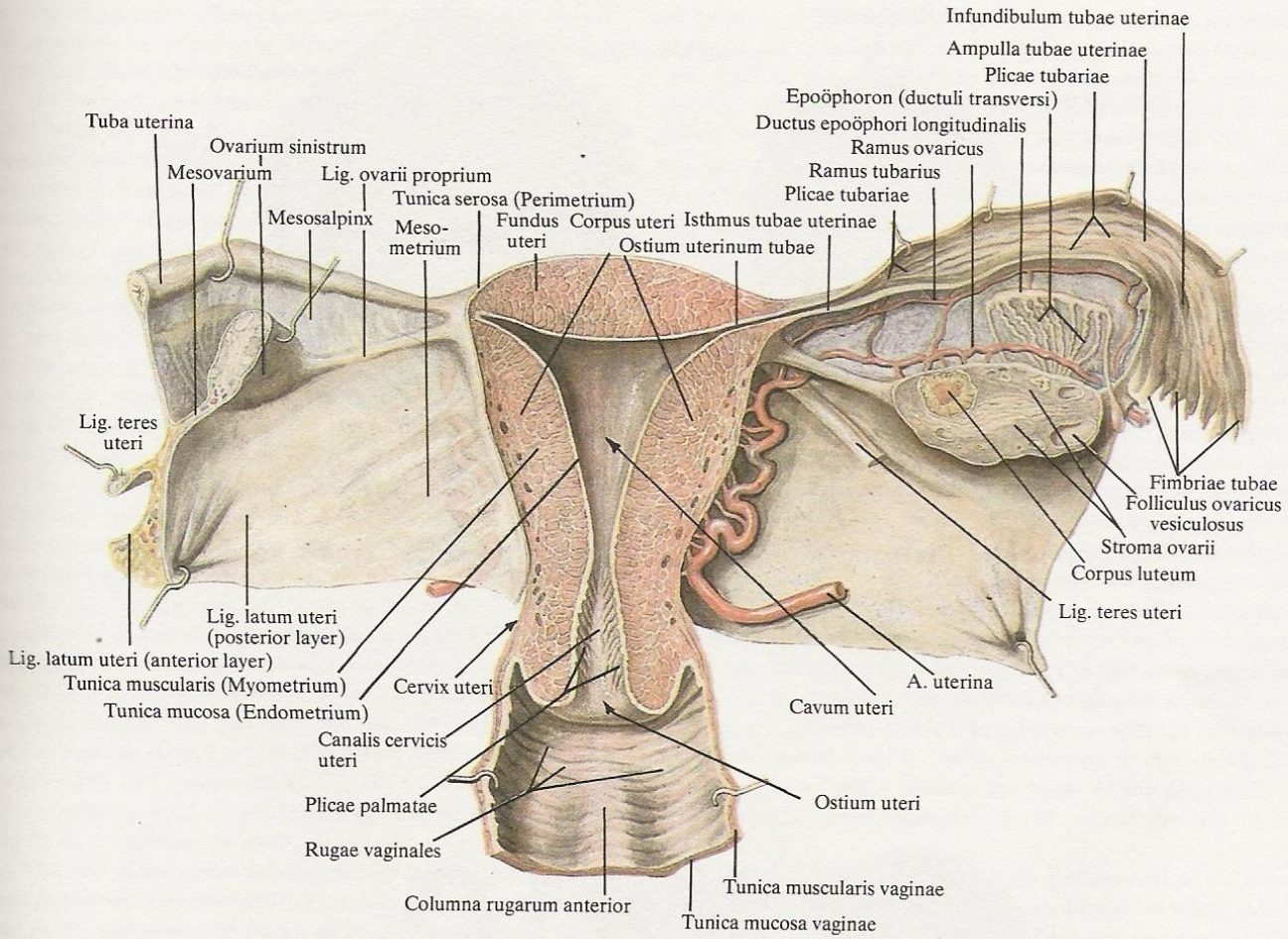
Innervation and blood supply of the uterine tube: see *The Uterus.*

THE EPOÖPHORON

The **epoöphoron** (Figs 564, 565) lies between the peritoneal layers of the broad ligament of the uterus in the lateral part of the mesosalpinx between the ovary and the uterine tube.

It consists of a fine network of tortuous **tubules of the epoöphoron** *(ductuli transversi)* and a longitudinal **duct of the epoöphoron** *(ductus epoöphori longitudinalis)*. The tubules are remnants of the caudal part of the mesonephros; they run from the hilum of the ovary to the uterine tube and open into the duct of the epoöphoron, which is a remnant of the mesonephric duct.

One or more inconstantly present vesicles called the **appendices vesiculosae** are suspended on a pedicle (sometimes very long) situated laterally of the epoöphoron and hanging from the meso-



565. *Section through uterus, uterine tube (tuba uterina), ovary (ovarium), and part of vagina;* posterior aspect (4/5).

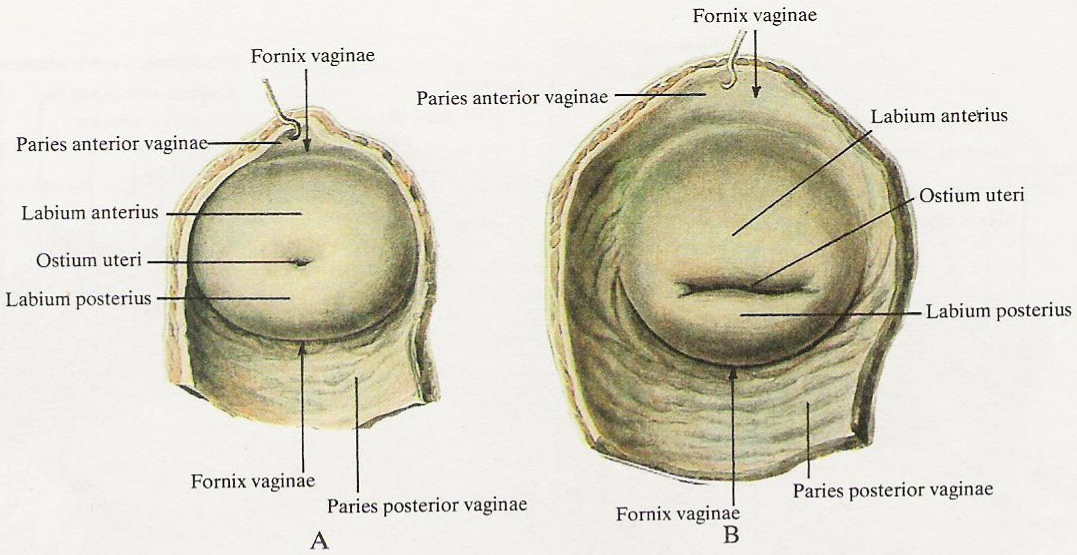
salpinx or a fimbria. They are the size of a small pea and filled with fluid.

The **paroöphoron** is a yellowish nodule of coiled tubules, a remnant of the tubules of the lower portion of the mesonephros. Macroscopically it has the appearance of a small tube closed on both ends, which lies medially of the epoöphoron between the layers of the peritoneum.

THE UTERUS

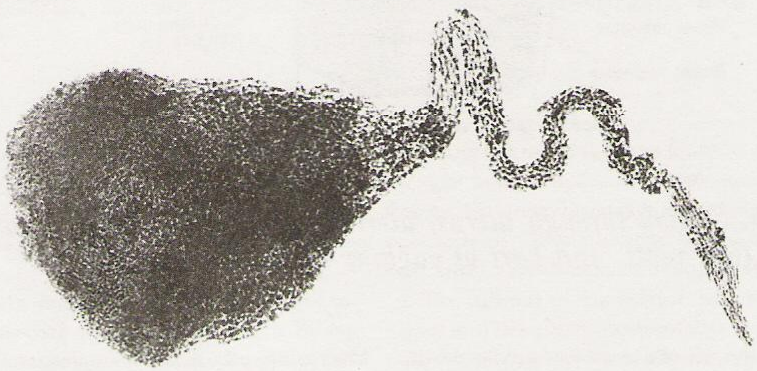
The **uterus** *(metra)* (Figs 562–566, 572) is an unpaired hollow organ composed of smooth muscles and situated in the cavity of the true pelvis, between the pubic symphysis and sacrum; its highest part, the fundus, does not protrude beyond the level of the inlet of the pelvis. The uterus is pear-shaped and flattened from front to back. Its wide part is directed upwards and to the front, the narrow part faces downwards and forwards. The shape and size of the uterus change considerably in the different periods of life, particularly in connection with pregnancy. The uterus measures 7–8 cm in length in a nulliparous woman, and 8–9.5 cm in a woman who has borne children; it is 4–5.5 cm wide at the level of the fundus and its weight varies from 30 to 100 g.

The neck, body, and fundus are distinguished in the uterus (Fig. 564).



566. *Vaginal part of neck of uterus (portio vaginalis cervicis uteri);* inferior aspect (1/1).

A—before childbirth; B—after childbirth



567. *Uterine gland* (specimen prepared by N. Brovina). (Photomicrograph.)

(Isolated gland from a totally stained mucous coat of the uterus of a pregnant woman.)

The **neck of the uterus** *(cervix uteri)* is either gradually continuous with the body or sharply demarcated from it. It is about 3 cm in length and is divided into two parts: supravaginal and vaginal. The upper two-thirds of the neck are situated higher than the vagina and constitute the **supravaginal part** (*portio supravaginalis* s. *cervicis*). The lower third of the neck is as if pushed into the vagina and forms the **vaginal part** (*portio vaginalis* s. *cervicis*). On its lower end is a round or oval orifice called the **external os uteri** *(ostium uteri)* whose borders form the **anterior lip** *(labium anterius)* and **posterior lip** *(labium posterius)*. The os uteri is a transverse slit in women who have borne children and rounded in nulliparous women. The posterior lip is slightly longer but thinner than the anterior lip and is situated higher. The os uteri faces the posterior wall of the vagina.

In the neck of the uterus is the **canal of the cervix** *(canalis cervicis uteri)* whose width differs along its course: it is wider in the middle parts than in the region of the internal and external orifices, as a result of which it is spindle-shaped.

The **body of the uterus** *(corpus uteri)* is triangular with a truncated lower angle which is continuous with the neck. The body is separated from the neck by a narrowed part called the **isthmus of the uterus** *(isthmus uteri)* which corresponds to the position of the internal orifice of the uterus. The body of the uterus has an anterior, **vesical surface** *(facies vesicalis)*, a posterior, **intestinal surface** *(facies intestinalis)*, and a **right** and **left borders** (*margines uteri dexter et sinister*) at the junction of the two surfaces. The upper part of the uterus, which is raised like a dome above the openings of the uterine tubes, is called the **fundus of the uterus** *(fundus uteri)*. It is a convexity joining each border of the uterus at an angle into which the uterine tubes enter. The cite of tube entry is called the horn of the uterus.

The **cavity of the uterus** *(cavum uteri)* (Fig. 565) measures 6–7 cm in length. Its frontal section has the shape of a triangle in whose upper angles are the openings of the uterine tubes, and in the lower angle is the internal orifice of the uterus, which leads into the canal of the cervix. The size of the cavity in nulliparous women differs from that in women who have borne children: the bulging of the borders into the uterus is more pronounced in the former. The vesical surface of the body of the uterus comes in contact with the intestinal surface as the result of which the cavity is seen as a slit on sagittal section. The lower, narrow part of the cavity (Figs 565, 566) communicates with the **canal of the cervix** *(canalis cervicis uteri)* which is spindle-shaped. The canal opens into the vagina by the **external os uteri** *(ostium uteri)*.

The wall of the uterus consists of three layers: the outer serous coat *[tunica serosa (perimetrium)]*, the subserous coat *(tela subserosa)*, the middle muscular coat *[tunica muscularis (myometrium)]*, and the inner **mucous coat** *[tunica mucosa (endometrium)]*.

The **serous coat** of the uterus, or **perimetrium** *(tunica serosa)* is a direct continuation of the serous coat of the urinary bladder. It is intimately fused with the myometrium for a great distance on the anterior and posterior surfaces and on the fundus, but is attached loosely in the region of the isthmus.

The **muscular coat of the uterus**, or **myometrium** *(tunica muscularis)* is the thickest and strongest layer of the wall of the uterus. It is made up of three layers of smooth muscle fibres with an admixture of fibrous connective tissue and elastic fibres. The muscle fibres of the three layers interlace in various directions, as a result of which separation into the layers is indistinct. The thin outer (subserous) layer consisting of longitudinal fibres and a few circular fibres, is intimately fused with the serous coat. The middle, circular layer is developed best. It is composed of rings which are arranged perpendicularly to the axis of the tubes in the region of the angles, and circularly and obliquely in the region of the body of the uterus. This layer contains many vessels (mainly venous) and is therefore also called *stratum vasculosum*. The inner (submucous) layer is the thinnest and its fibres run longitudinally.

The **mucous coat of the uterus**, or **endometrium** *(tunica mucosa)* is fused with the muscular coat and, consequently, forms the lining of the cavity of the uterus without a submucous coat. In the region of the uterine openings of the tubes it is continuous with their mucous coat; in the region of the fundus and body its surface is smooth. On the anterior and posterior walls of the canal of the cervix the mucous coat *(endocervix)* forms longitudinal folds called **arbor vitae** *(plicae palmatae)*. The mucous coat of the uterus consists of single-layer columnar ciliated epithelium; it contains tubular **uterine glands** *(glandulae uterinae)* (Fig. 567), those in the region of the cervix are called the **cervical glands of the uterus** *(glandulae cervicales uteri)*.

The uterus occupies the central position in the cavity of the true pelvis. To the front of it, touching its vesical surface, is the urinary bladder, to the back are the rectum and the loops of the small intestine. An upper, intraperitoneal part (the fundus, body, and part of the neck) and a lower, extraperitoneal part are distinguished in the uterus. The peritoneum covers the vesical and intestinal surfaces of the uterus and passes to the adjacent organs: in front, at the level of the middle of the hight of the neck, it passes over to the bladder as a result of which the uterovesical pouch *(excavatio vesicouterina)* forms here; posteriorly the peritoneum descends on the surface of the body of the uterus to the neck, then passes downwards on the posterior wall of the vagina, and passes over to the anterior wall of the rectum. The peritoneal pouch between the uterus and rectum is called rectouterine *(excavatio rectouterina)*. On the sides, where it is continuous with the broad ligaments, the peritoneum is loosely connected to the uterus. The **parametrium** is lodged between the layers of the peritoneum in the base of the broad ligaments at the level of the neck of the uterus.

The lower half of the anterior surface of the neck of the uterus is devoid of a serous coat and is separated from the upper part of the posterior wall of the bladder by a connective-tissue septum fastening both organs to each other. The lower part of the uterus, the neck, is fastened to the vagina which begins from it.

The uterus does not take a vertical position in the cavity of the true pelvis but bends forwards *(anteversio)* as a result of which its body is tilted above the anterior surface of the bladder. The axis of the body of the uterus meets that of the neck at an angle of 70–100° open forwards *(anteflexio)*. Besides, the uterus may deviate to the right or left from the midline (*lateropositio dextra* or *lateropositio sinistra*). The tilting of the uterus changes when the urinary bladder or rectum is filled.

The uterus is held in place by several ligaments: the paired round ligament of the uterus, the right and left broad ligaments, and the paired rectouterine ligament (muscle) and uterosacral ligament.

The **round ligament of the uterus** *(ligamentum teres uteri)* (Figs 563–565, 572) is a band of connective tissue and smooth-muscle tissue measuring 10–15 cm in length. It arises from the border of the uterus directly below and to the front of the uterine tube.

The round ligament is embedded in the peritoneal fold at the beginning of the broad ligament and passes to the lateral wall of

the true pelvis, and then upwards and forwards to the deep inguinal ring. The broad ligament crosses along its course the obturator vessels and nerve (*vasa obturatoria* et *nervus obturatorius*), the lateral umbilical ligament, the external iliac vein *(vena iliaca externa)*, and the inferior epigastric vessels *(vasa epigastrica inferiora)*. After passing in the inguinal canal the ligament leaves it through the superficial inguinal ring and distributes in the subcutaneous areolar tissue in the region of the mons pubis and the labium majus.

In the inguinal canal the round ligament is attended by: the artery to the round ligament of the uterus *(arteria ligamenti teretis uteri)*, the genital branch of the genitofemoral nerve *(ramus genitalis)*, and bundles of muscle fibres from the internal oblique muscle *(musculus obliquus internus abdominis)* and the transversus abdominis muscle *(musculus transversus abdominis)*.

The **broad ligament of the uterus** *(ligamentum latum uteri)* (Figs 562, 565) is formed of two peritoneal layers, anterior and posterior, stretching from the uterus to both sides to the lateral wall of the true pelvis. On reaching the wall and the floor of the pelvis, the layers are continuous with the parietal peritoneum of the true pelvis. At the base of the broad ligament between its layers are connective-tissue bands containing smooth muscle fibres. They form the cardinal ligament on both sides of the uterus. This ligament contributes significantly to fixation of the uterus and vagina. Medially the tissue of this ligament is continuous with the parametrium surrounding the neck of the uterus and the upper part of the sides of the vagina (at the level of its fornix).

The ureter, uterine artery *(arteria uterina)*, and the uterovaginal plexus *(plexus uterovaginalis)* pass in the parametrium.

The uterine tube lies between the layers of the upper border of the broad ligament. The posterior layer of the lateral part of the broad ligament gives rise to the **mesovarium** below the ampulla of the uterine tube. Inferior to the medial part of the tube on the posterior surface of the broad ligament is the **ligament of the ovary** *(ligamentum ovarii proprium)* (Figs 564, 565).

The area of the broad ligament between the tube and the mesovarium is called the **mesosalpinx** which encloses, nearer to its lateral parts, the ovarian fimbria *(fimbria ovarica)*, the epoöphoron, and the paraoöphoron. The superolateral border of the broad ligament forms the **infundibulopelvic ligament** *(ligamentum suspensorium ovarii)*.

The round ligament of the uterus *(ligamentum teres uteri)* is seen on the anterior surface of the beginning of the broad ligament.

Ligaments which are lodged in the right and left recto-uterine folds should be related to the immobilizing apparatus of the uterus. These two ligaments contain connective-tissue bands and fibres of the recto-uterine muscle and stretch from the neck of the uterus to the lateral surfaces of the rectum and the pelvic surface of the sacrum.

Innervation: the hypogastric, uterine, and uterovaginal plexuses (*plexus hypogastricus, uterinus* et *uterovaginalis*).

Blood supply: the uterine and ovarian arteries *(arteriae uterina* et *ovarica)*.

THE VAGINA

The **vagina** (Figs 562–565) is a tubular organ flattened from front to back. It measures 8–10 cm in length. Its upper boundary is on the level of the neck of the uterus which it embraces. Inferiorly it opens into the vestibule by the **orifice of the vagina** *(ostium vaginae)*. The vagina is directed downwards and forwards in line with the axis of the lower part of the true pelvis and forms an angle open to the front in relation to the uterus. The **anterior wall** *(paries anterior)* and the **posterior wall** *(paries posterior)* of the vagina are in contact as the result of which its cavity is slit-like. The anterior wall is thicker than the posterior wall because the tissue of the urethra is fused with it.

At the very top the cavity of the vagina forms a blind recess around the neck of the uterus projecting into it; this is the **fornix of the vagina** *(fornix vaginae)*. The part of the fornix between the posterior lip of the os uteri and the posterior wall of the vagina is deeper than the part between the anterior lip of the os uteri and the anterior wall of the vagina (Fig. 563). Connective tissue containing a small number of smooth muscle fibres surrounds the wall of the vagina and is especially thick in the lower parts where it is connected to the rectum, bladder, and urethra.

The walls of the vagina consist of two layers: the muscular and mucous coats.

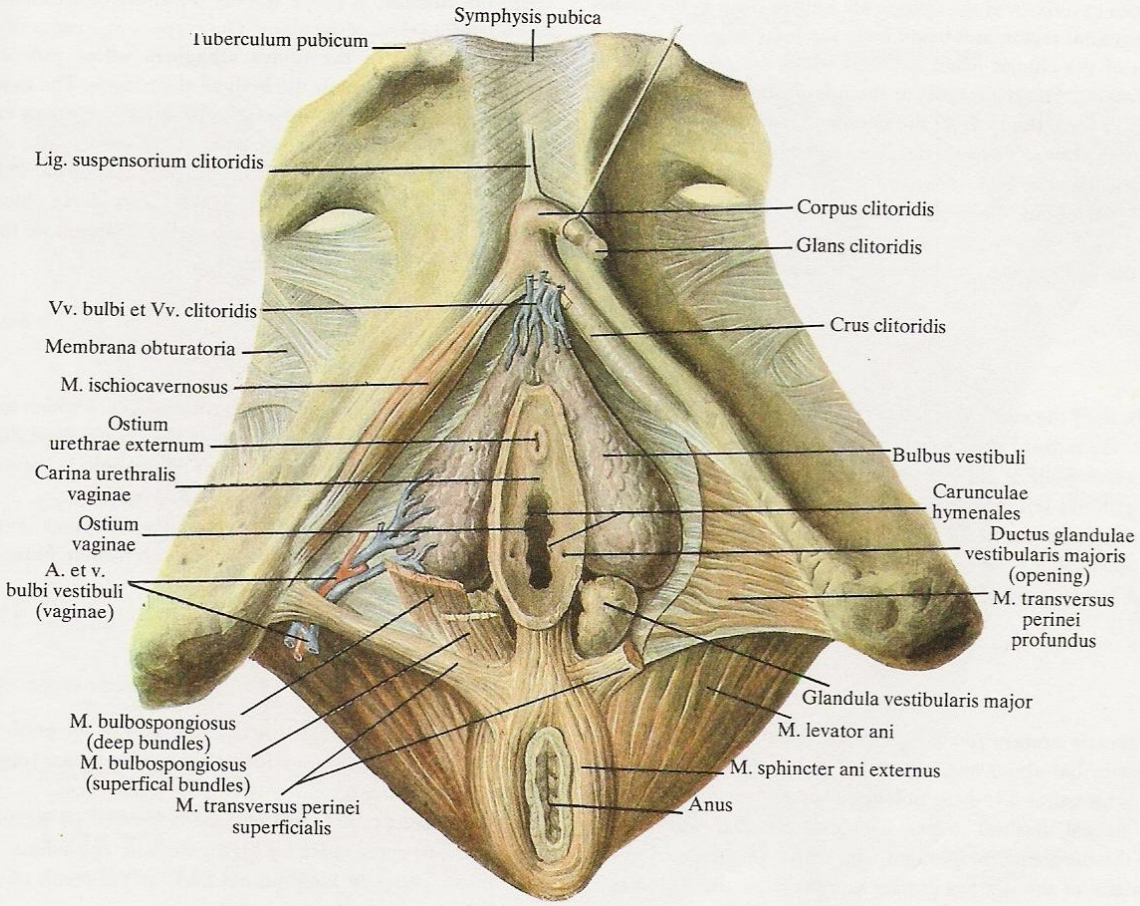
The **muscular coat** *(tunica muscularis)* is formed of two layers of muscles: an outer longitudinal and an inner circular layer. The fibres of both layers partly interlace. The longitudinal muscle bundles run upwards to be continuous with the muscular layer of the neck of the uterus.

The muscles of the floor of the pelvis send bundles of striated muscle fibres into the wall of the vagina in the region of the urogenital diaphragm; the upper part of the vagina contains only smooth muscle fibres.

The **mucous coat** *(tunica mucosa)* is intimately fused with the muscular coat by means of lamina propria. The mucous coat is much thicker than the muscular coat—up to 2 mm thick in some places. It bears transverse ridges called the **vaginal rugae** *(rugae vaginales)* (Fig. 565), particularly in the lower part. They project more in the middle areas of the anterior and posterior walls of the vagina than on the sides, as a result of which longitudinal elevations form which are called the **anterior** and **posterior columns of the rugae** (*columnae rugarum anterior* et *posterior*). They are developed better in the lower than in the upper parts of the vagina. The lower end of the anterior column is known as the **urethral ridge of the vagina** *(carina urethralis vaginae)* because of the underlying lower part of the urethra.

All these folds make the mucous coat, and with it all the layers of the wall of the vagina, very stretchable, which provides for better passage of the foetus along the birth canal.

The walls of the vagina are related to the organs of the true



569. *Corpora cavernosa of clitoris and bulbs of vestibule of vagina;* inferior aspect (1/1).

THE GREATER VESTIBULAR GLANDS

The **greater vestibular gland** *(glandula vestibularis major)* is paired and situated in the base of each labium majus under the posterior end of the bulb of the vestibule and the bulbospongiosus muscle; it is sometimes encircled by muscle fibres. Each gland is rounded in shape, the size of a large pea, and yellowish-red in colour.

The single duct of each gland measures up to 2 cm in length; it runs forwards, and its small opening is in the vestibule of the vagina on the medial surface of the labium minus, at the junction of the posterior and middle third.

It is a compound-tubular gland and corresponds to the bulbourethral gland in males.

THE CLITORIS

The **clitoris** (Figs 562, 568, 569) is an unpaired structure situated behind and below the anterior commissure of the labia majora, between their anterior parts. It is small and flattened slightly on the sides. The clitoris consists of the **right** and **left corpus cavernosum** (*corpora cavernosa clitoridis dexter* et *sinister*) which correspond to the corpora cavernosa of the penis but are much smaller.

The corpora cavernosa of the clitoris are hidden deep in the tissues of the urogenital region and begin from the inferior pubic rami by two **crura of the clitoris** *(crura clitoridis)* which are covered by the perineal fasciae. The crura unite at the inferior border of the pubic symphysis to form the **body of the clitoris** *(corpus clitoridis)* which is directed downwards. The anterior, free end of the body forms the **glans of the clitoris** *(glans clitoridis)* which is covered with a fine skin layer resembling the mucous membrane in colour. The glans is situated in the upper part of the pudendal cleft and protrudes between the ends of the labia minora. The **prepuce of the clitoris** *(preputium clitoridis)* is above and the **frenulum of the clitoris** *(frenulum clitoridis)* is below the glans. The corpora cavernosa of the clitoris are enclosed in the **tunica albuginea** whose processes form septa of erectile tissue in the body of the clitoris. The **median septum** *(septum corporum cavernosum)* separates the corpora cavernosa, and its processes penetrate the body of the clitoris and contribute to the formation of the septa of the corpora cavernosa. The clitoris, except for the glans, is enclosed in the **fascia of the clitoris** *(fascia clitoridis)* and fastened by the **suspensory ligament of the clitoris** *(ligamentum suspensorium clitoridis)*.

THE BULB OF THE VESTIBULE

The **bulb of the vestibule** *(bulbus vestibuli)* (Figs 562, 569) corresponds to the bulb of the penis but possesses some distinguishing features. The bulb is an unpaired structure consisting of two halves, right and left, which unite by means of a small intermediate part situated between the clitoris and the external orifice of the urethra. Each of the two halves is a dense venous plexus whose elongated lateral portions are embedded in the base of the labia majora; it is a flattened spindle-shaped structure which thickens to the back and its posterior end covers the greater vestibular gland.

Laterally and inferiorly each half of the bulb is covered by the bulbospongiosus muscle *(musculus bulbospongiosus)*.

The bulb of the vestibule has a tunica albuginea investing the venous plexus which is pierced by smooth muscle fibres and connective-tissue bundles.

THE FEMALE URETHRA

The **female urethra** *(urethra feminina)* (Figs 563, 568, 569) is a canal shorter but about one and a half times wider than the male urethra; it measures 3 to 4 cm in length. It begins from the bladder by the **internal urethral orifice** *(ostium urethrae internum)*, passes through the urogenital diaphragm, and opens by means of the **external orifice of the urethra** *(ostium urethrae externum)* in the vestibule of the vagina, deep in the pudendal cleft. The external orifice is rounded and its elevated edges are hard to the touch. The urethra runs parallel to the vagina on the anterior wall, to which it is fused, and is directed downwards and forwards to pass under the pubic symphysis. The size of the lumen is irregular along the course of the canal: it is dilated like a funnel at the bladder and narrow at the external orifice. The urethra is enclosed in connective tissue which is thickest in the region of the lower parts of the vagina.

The wall of the urethra is formed by muscular and mucous coats.

The **muscular coat** *(tunica muscularis)* is composed of an outer, circular layer and an inner, longitudinal layer of smooth muscles with an admixture of elastic fibres. The muscles of the urogenital diaphragm send fibres into the circular layer of the urethra to form the sphincter urethrae muscle *(musculus sphincter urethrae)* (see *The Urogenital Diaphragm*).

The **mucous coat** *(tunica mucosa)* is covered by stratified squamous, and in some cases by high prismatic epithelium and gathered into a series of longitudinal folds as the result of which the urethra lumen is stellate on section.

The largest and highest fold on the posterior wall is called the **urethral crest** *(crista urethralis)*; it stretches from the anterior angle of the trigone of the bladder to the end of the canal. The ducts of the **urethral glands** *(glandulae urethrales)* open on the mucous membrane in the lower portions of the urethra.

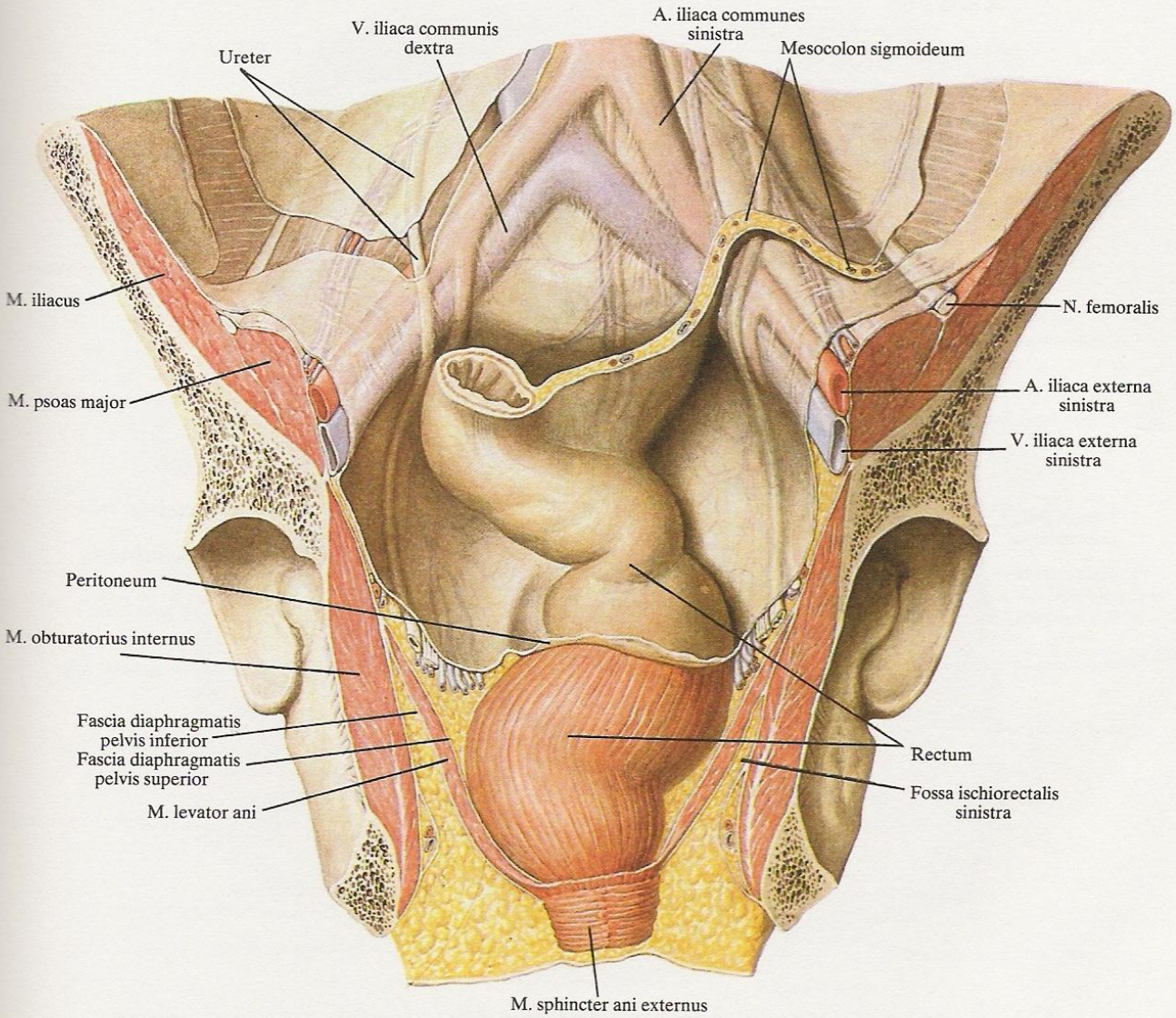
The **lacunae urethrales** are situated on the surface of the mucous coat. Close to the external orifice of the urethra, on either side, is the opening of the common duct of small glands embedded here.

Innervation: the hypogastric, pudendal, and lumbar plexuses (*plexus hypogastricus*, *pudendus* et *lumbalis*).

Blood supply: the internal and external pudendal arteries (*arteriae pudenda interna* et *externa*).

THE PERITONEUM OF THE CAVITY OF THE FEMALE TRUE PELVIS

On descending from the cavity of the abdomen on the posterior wall, the parietal peritoneum passes over the arcuate line *(linea terminalis)* into the cavity of the true pelvis in the female (Figs 562, 572) and covers mesoperitoneally the anterior surface of the middle third of the rectum. After that the peritoneum passes to the posterior fornix of the vagina and, ascending, covers the posterior

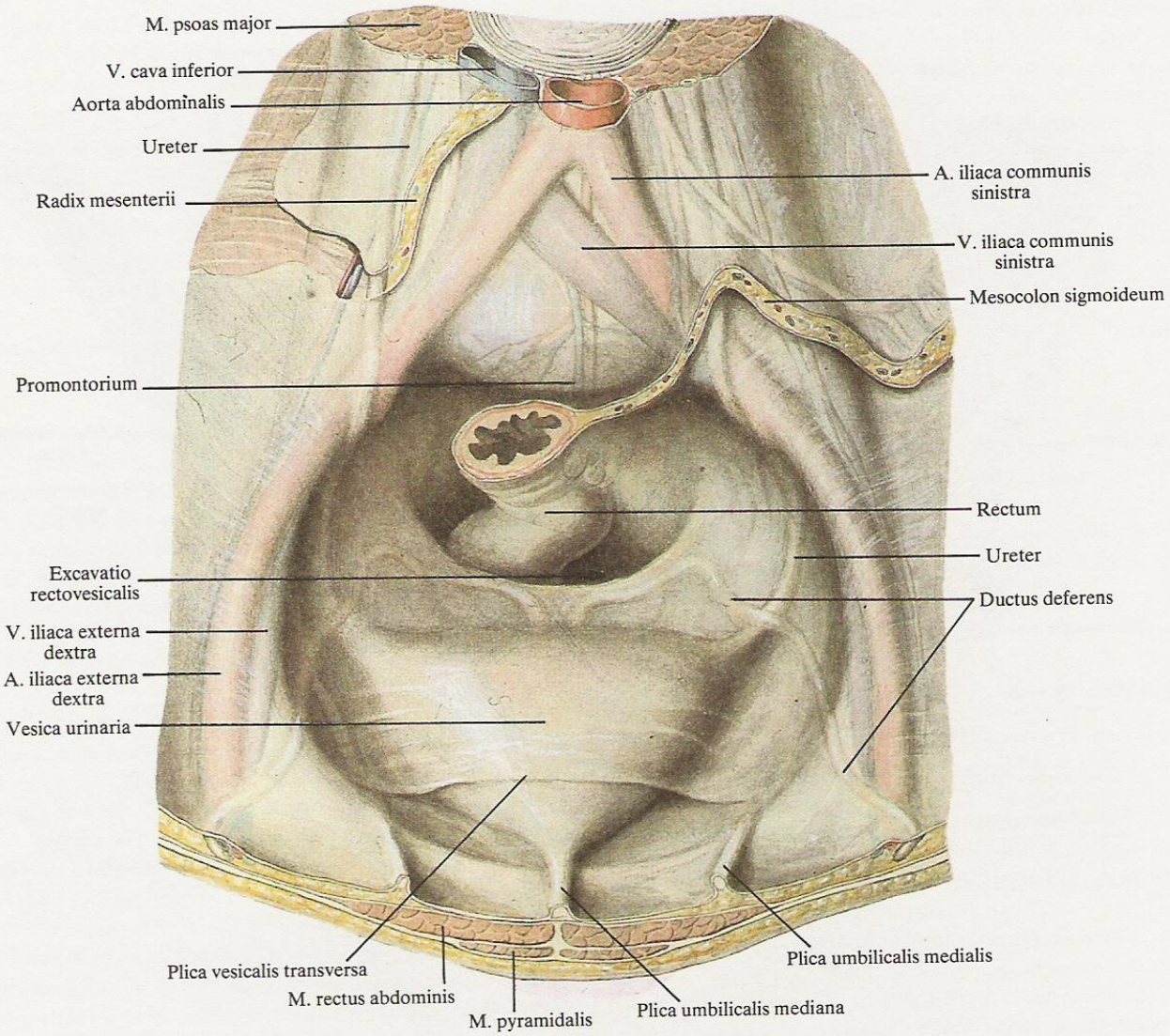


570. *Peritoneum and fasciae of floor of true pelvis;* anterior aspect (1/1).

(The front parts of the pelvis and the urogenital organs are removed.)

surface of the uterus to its fundus. Here it again descends and covers the anterior surface of the body of the uterus to its neck. The peritoneum is then reflected to the posterior surface of the urinary bladder, ascends on it, reaches the apex of the bladder, and is continuous with the parietal peritoneum lining the anterior abdominal wall. Thus, the peritoneum forms in relation to the uterus two pouches lying in the frontal plane: one is formed between the rectum and the uterus and is called the **recto-uterine**, or **recto-vaginal**, **pouch** *(excavatio rectouterina)*, and the other is between the uterus and the bladder and is known as the **uterovesical pouch** *(excavatio vesicouterina)* (Fig. 563). The first pouch is much deeper and bounded on the sides by the **recto-uterine folds** *(plicae rectouterinae)* in which poorly developed recto-uterine muscles containing smooth muscle fibres are embedded. The second, uterovesical, pouch is smaller than the first and its depth depends on the extent of the bladder filling.

Both pouches are separated from one another by the broad ligaments of the uterus which are folds of the peritoneum.

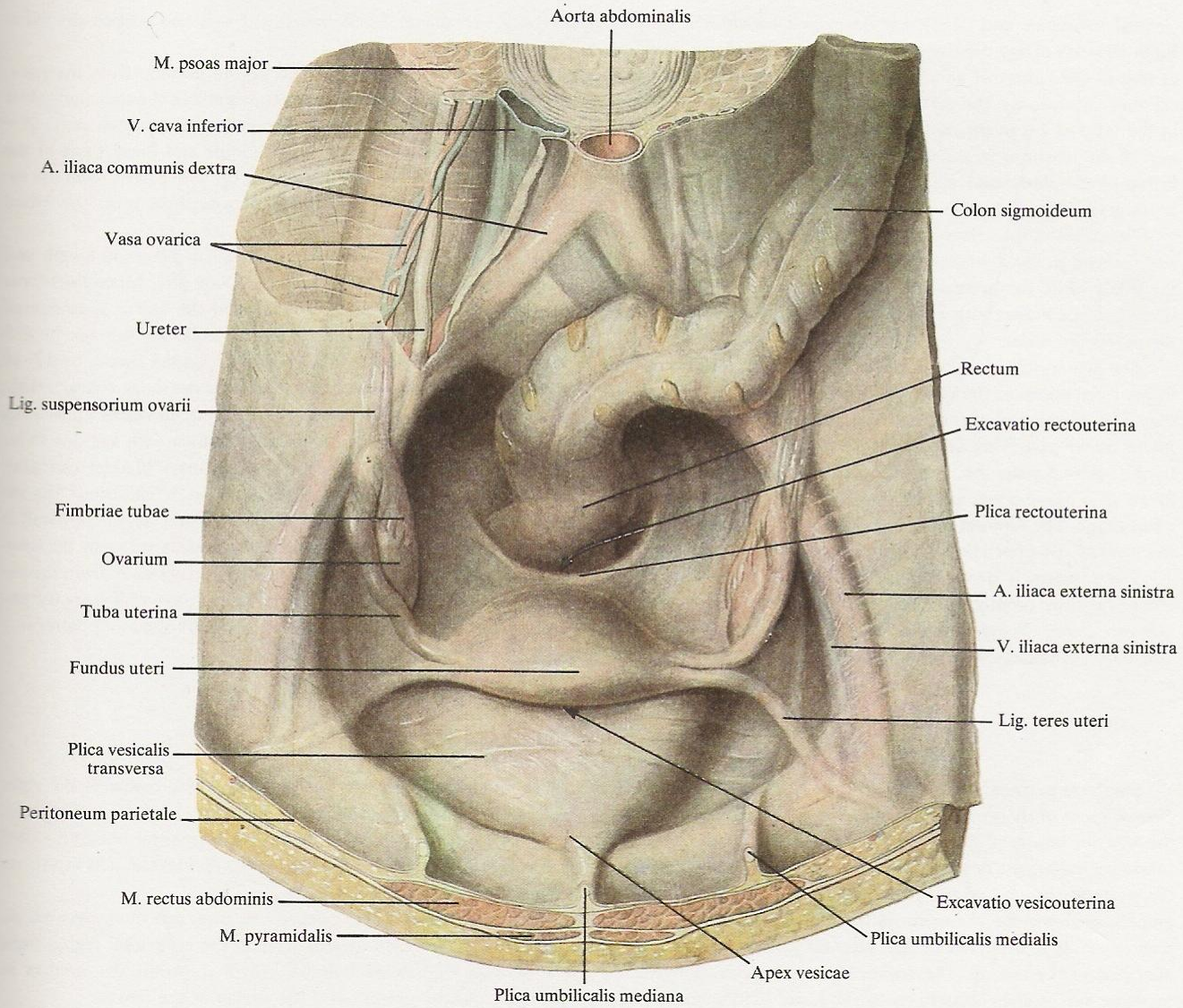


571. *Relation of peritoneum to organs of true pelvis (male);* superior aspect (½).

DEVELOPMENT AND AGE FEATURES OF THE ORGANS OF THE UROGENITAL SYSTEM

The urinary and genital organs are interrelated developmentally despite their different functional features. The mesoblast takes part in the formation of the organs of the urogenital system; it gives rise to the kidneys and reproductive glands. The ectoblast lining the cloaca and the entoblast of the dorsal part of hindgut take part in the formation of the efferent urinary and genital ducts and the reproductive organs. The organs of the urinary system—the kidneys—are laid down a little earlier than the reproductive organs and go through three developmental stages: pronephros, mesonephros, and metanephros.

The pronephros is laid down in the middle of the third week, the mesonephros—in the middle of the fourth week of intra-uterine life and reduces rapidly, taking part in the development of the male efferent genital ducts. Both these stages are superseded in the intra-uterine period by the stage of the permanent kidney which persists throughout life.



572. *Relation of peritoneum to organs of true pelvis (female);* superior aspect (½).

The lobate structure (14 lobes on the average) is seen distinctly in the kidneys of the newborn but disappears by the age of 2 to 4 years (Fig. 546).

The kidney of the newborn measures 3.5–3.7 cm in length, 1.7–2.1 cm in breadth, and 1.6 cm in thickness; it weighs 11–12 g. At the beginning of the second year of life the size almost doubles. The upper end of the kidney is at the level of the lower border of the body of the eleventh thoracic vertebra in the newborn, at the level of the middle of the twelfth thoracic vertebra at the age of 3–5 months of life, and reaches the level of the adult by the age of 2 years. The lower end of the right kidney is on the level of the lower border of the fourth lumbar vertebra, that of the left kidney is at the level of the middle of the body of this vertebra. In accordance with the described position of the kidneys, the renal arteries and veins run obliquely in relation to the origin from the aorta and emptying into the inferior vena cava.

The position of the hilum of the kidney is on the level of the second lumbar vertebra in the newborn and at the level of the first lumbar vertebra in the adult.

Section of the kidney of the newborn shows a poorly developed

cortical substance and deficiently developed convoluted tubules. By 9–10 years of age the cortical substance has the same structure as that in the kidney of an adult. The medullary substance develops more intensively: the cortical and the medullary substance are in the ratio of 1:4 in the newborn and 1:2 in the adult. Each kidney of the newborn is enclosed in its own capsule and attached firmly to the suprarenal gland by connective tissue which disappears gradually with age.

The pelvis of the ureter and the ureter itself have some distinctive features in the newborn. The pelvis is relatively wider than in the adult while the ureters are more tortuous. There are indications that in a kidney with a distinct lobate structure the pelvis and the ureter are wider.

The urinary bladder develops from a mesodermal germ which forms from union of the ventral part of the cloaca with the allantois. The bladder of the newborn is spindle-shaped with a narrowed upper part. This shape is retained to the age of 18 months, by the age of 5 years the bladder is shaped like a plum, by the age of 10 it is egg-shaped, and by the age of 15–17 it acquires the adult shape. The internal urethral orifice in the newborn is often at the level of the upper border of the symphysis.

The prostate is derived from the urethral epithelium by the end of the third month of the intrauterine period. The gland develops very slowly. It grows slightly in size by the age of 6–10 years and enlarges rapidly at puberty. The prostate is spherical in the newborn, becomes rather flattened with age, and is heart-shaped at 16 years of age.

The uterus, uterine tubes, and vagina develop from the paramesonephric ducts which undergo considerable changes along their course into the cavity of the future pelvis; their upper parts give rise to the uterine tubes, the fused middle and lower parts of the right and left ducts become the uterus, the lower parts form the vagina, while the mesenteries of the mesonephros form the broad ligaments of the uterus.

The uterus of the newborn measures 3.5–4.0 cm in length and weighs 2 g. A certain involution occurs soon after birth: the uterus becomes 2.5 cm long. In early childhood the uterus is elongated and slightly compressed from front to back. By the age of 8–9 years the body of the uterus acquires a rounded shape; by 12–14 years of age it is pear-shaped and then takes the shape characteristic of the uterus of an adult female. The vagina measures up to 3 cm in length in the newborn. Its position changes with age due to its gradual descent and the descent of the urinary bladder changing their topographo-anatomical relations. In early childhood the vagina forms an obtuse angle with the uterus and its anterior wall is slightly shorter than the posterior. The uterine tubes in the newborn are tortuous and their free ends are further away from the ovaries than those in an adult female. From the age of 5 years the position of the uterine tubes and ovaries acquire the adult pattern.

THE PERINEUM

The term **perineum** (Figs 573–577, 547, 562, 568, 570), in the narrow sense of the word, is applied to the area of tissues between the anterior border of the anus and the posterior border of the external genital organs or parts (the root of the scrotum in males and the posterior margin of the pudendal cleft in females). In topographic anatomy the perineum is the region of the outlet of the true pelvis. It is occupied by the external genital organs and the anal part of the rectum. The region of the perineum is rhomboid in shape and stretches anteriorly to the lower border of the pubic symphysis, posteriorly to the apex of the coccyx, and is bounded on both sides by the pubis, the ischium, and the sacrotuberous ligaments *(ligamenta sacrotuberalia)* and is separated from the thigh by the perineofemoral fold.

The **perineal region** *(regio perinealis)* forms the floor of the pelvis, thus closing its outlet. It is subdivided into an anterior, smaller **urogenital region** *(regio urogenitalis)* and a posterior, larger **anal region** *(regio analis)*. The outlet of the true pelvis is closed by muscles, fasciae, fat, and skin embedded differently in each region of the perineum.

A line slightly convex to the front, which connects the right and left ischial tuberosities, is the boundary of these two regions.

A ridge of skin situated on the medio-sagittal line and called the **raphe of the perineum** *(raphe perinei)* divides the skin in this region into the right and left halves.

The external genital organs, the urethra, and the urogenital diaphragm *(diaphragma urogenitale)* are in the urogenital region *(regio urogenitalis)*. The urogenital diaphragm transmits the urethra in the male and the urethra and the vagina in the female.

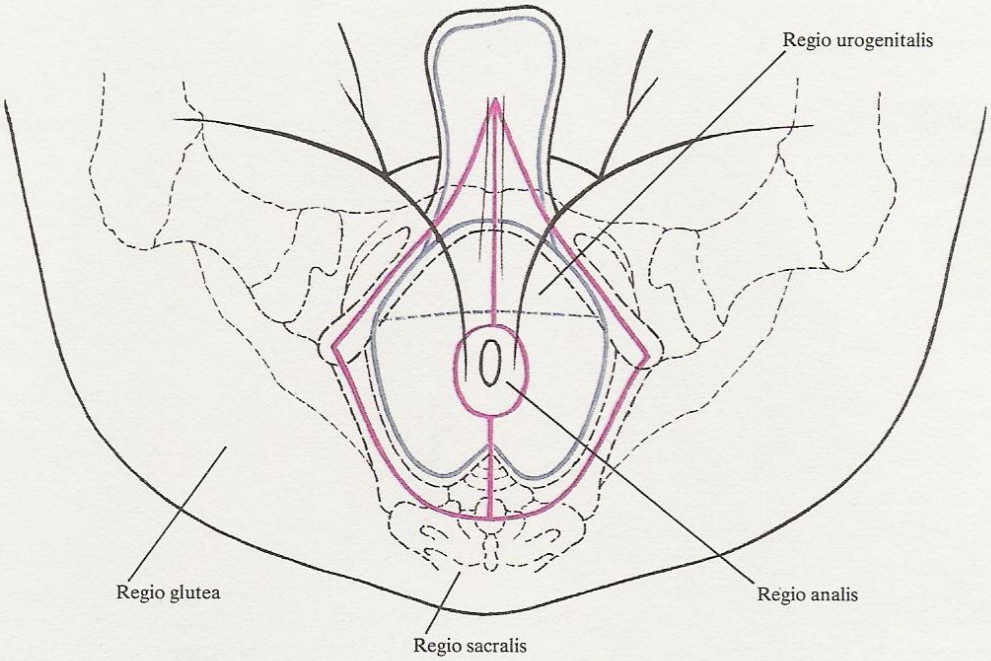
In the anal region *(regio analis)* are the anal canal *(canal analis)*, the rectum with the anus, the sphincter ani externus muscle, and the pelvic diaphragm *(diaphragma pelvis)*.

The two diaphragms, urogenital and pelvic, contribute to the formation of the floor of the pelvis.

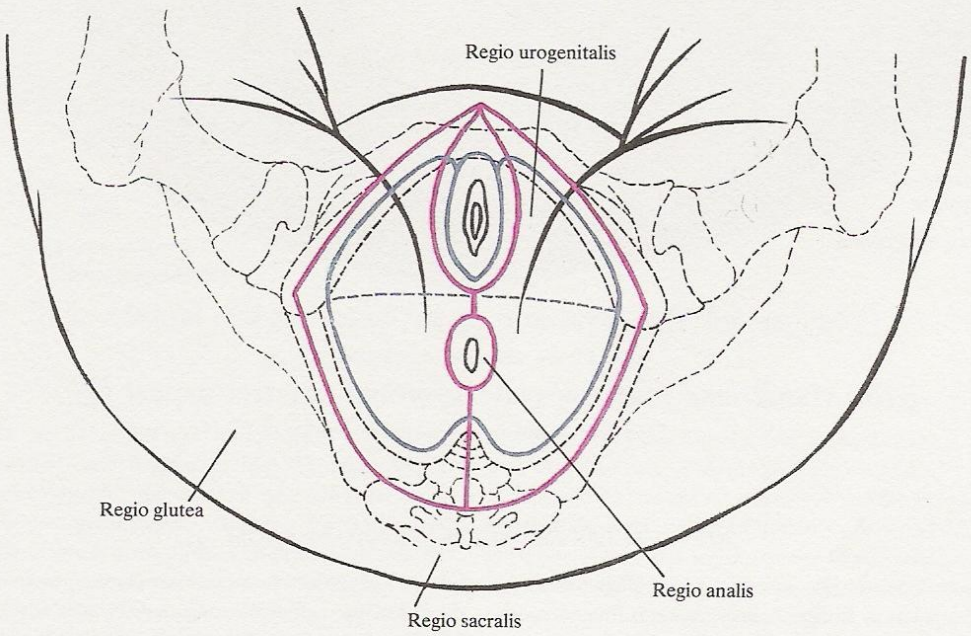
All the muscles of the perineum are divided into muscles of the terminal part of the intestine, which are components of the anal region, and muscles of the external genital parts, which belong to the urogenital region.

THE PELVIC DIAPHRAGM

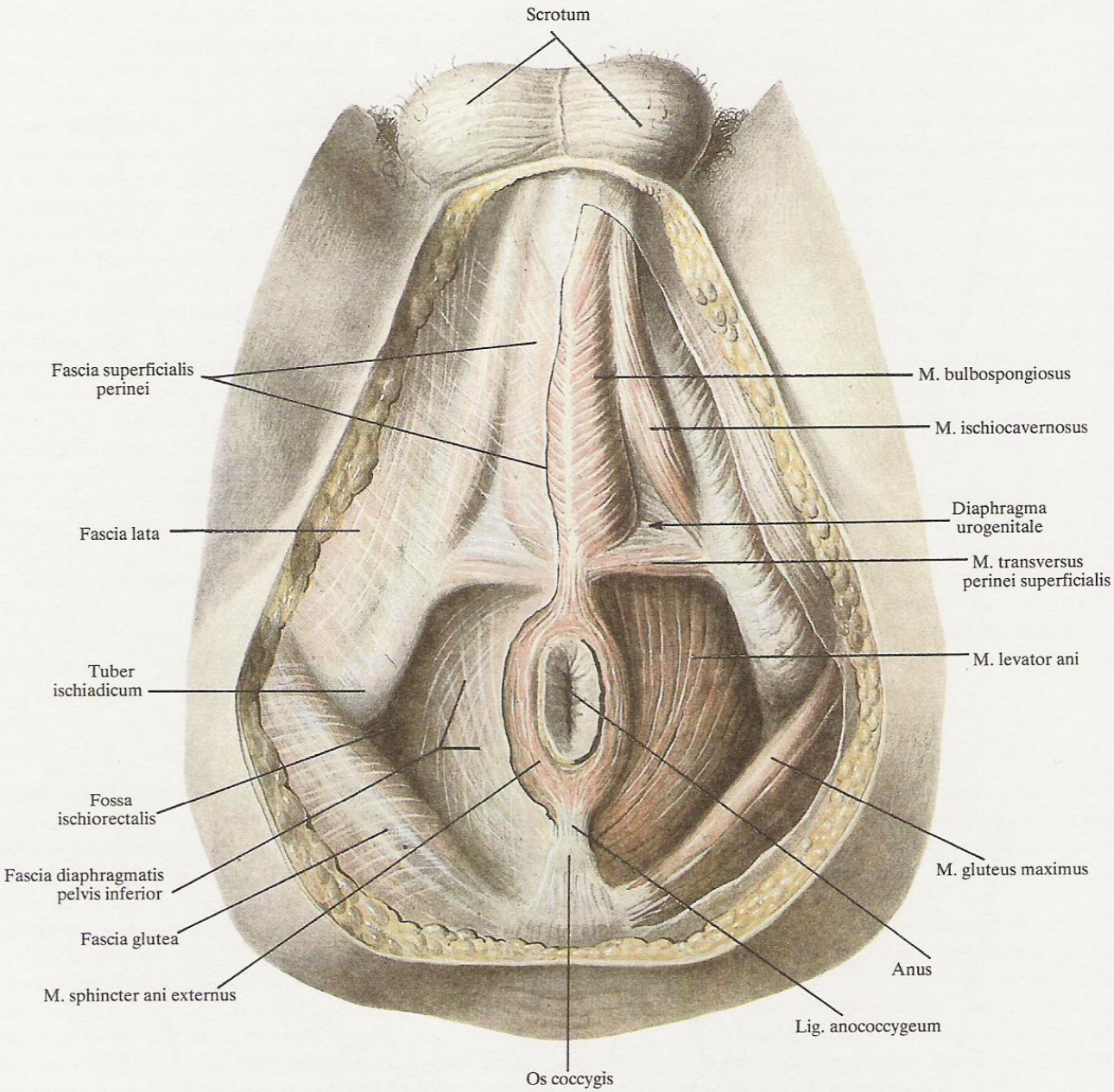
The **pelvic diaphragm** *(diaphragma pelvis)* (Fig. 577) is formed by the right and left levator ani muscles (*musculi levatores ani dexter et sinister*), the right and left coccygeus muscles (*musculi coccygei dexter et sinister*), the sphincter ani externus muscle, and fasciae.



573. *Regions and lines of skin incisions of male perineum.*
[Blue line—boundaries (outlines) of regions; red line—skin incisions.]



574. *Regions and lines of skin incisions of female perineum.*
[Blue line—boundaries (outlines) of regions; red line—skin incisions.]



575. *Muscles and fasciae of male perineum;* inferior aspect (3/2).

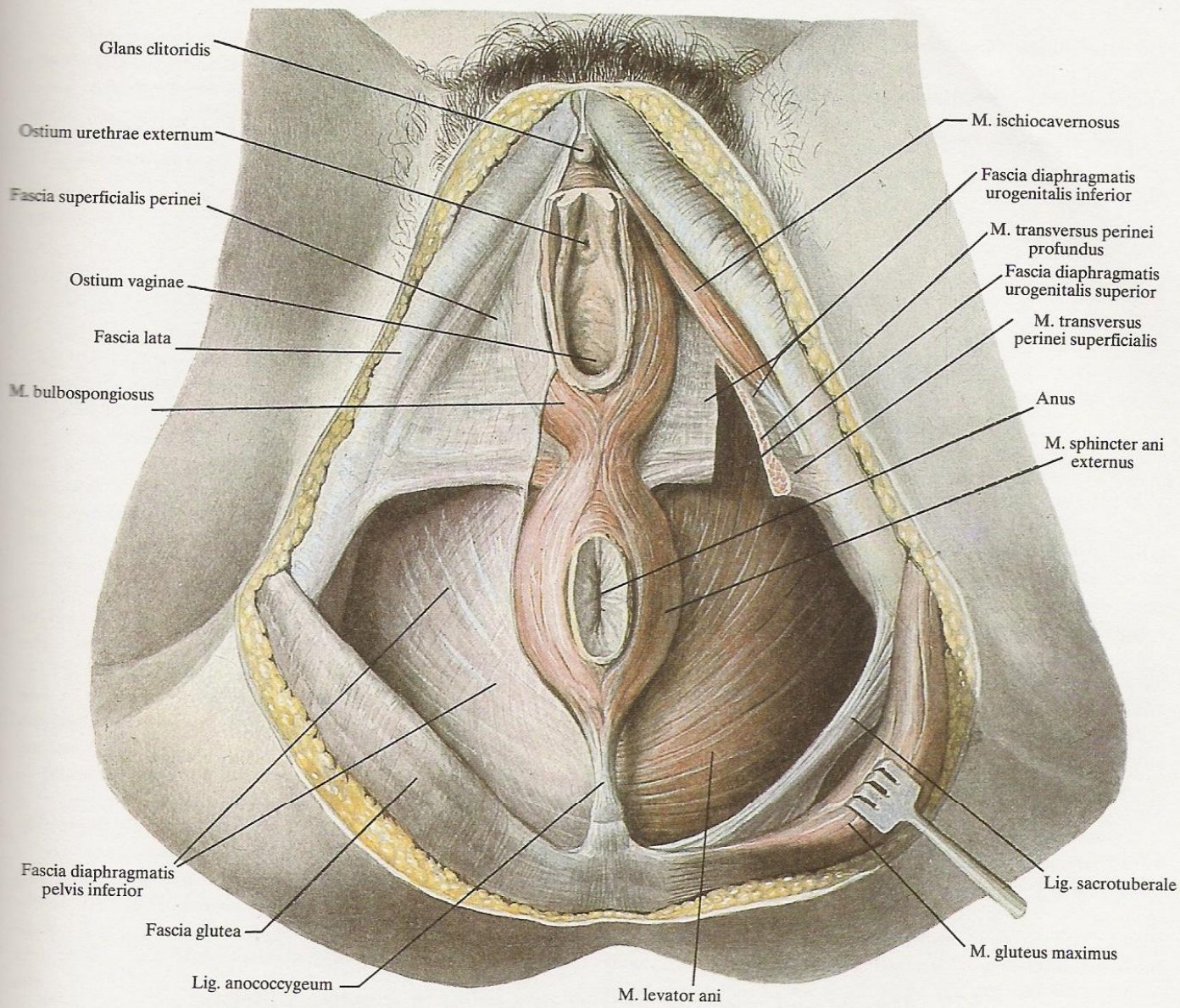
(The fasciae are removed on the left.)

THE MUSCLES OF THE PELVIC DIAPHRAGM

1. The **levator ani muscle** *(musculus levator ani)* (Figs 575–577) is triangular and consists of the pubococcygeus and iliococcygeus muscles and together with the fasciae forms a funnel-shaped muscular sheet which descends to the anus.

(a) The **pubococcygeus muscle** *(musculus pubococcygeus)*; its lateral part arises from the anterior part of the **tendinous arch of the levator ani muscle** *(arcus tendineus musculi levatoris ani)* which is a thickened part of the obturator fascia at the site of origin of the levator ani muscle and the fascia covering it.

The medial parts of the pubococcygeus muscle arise from the internal surface of the pubic rami near the superomedial part of the obturator foramen.

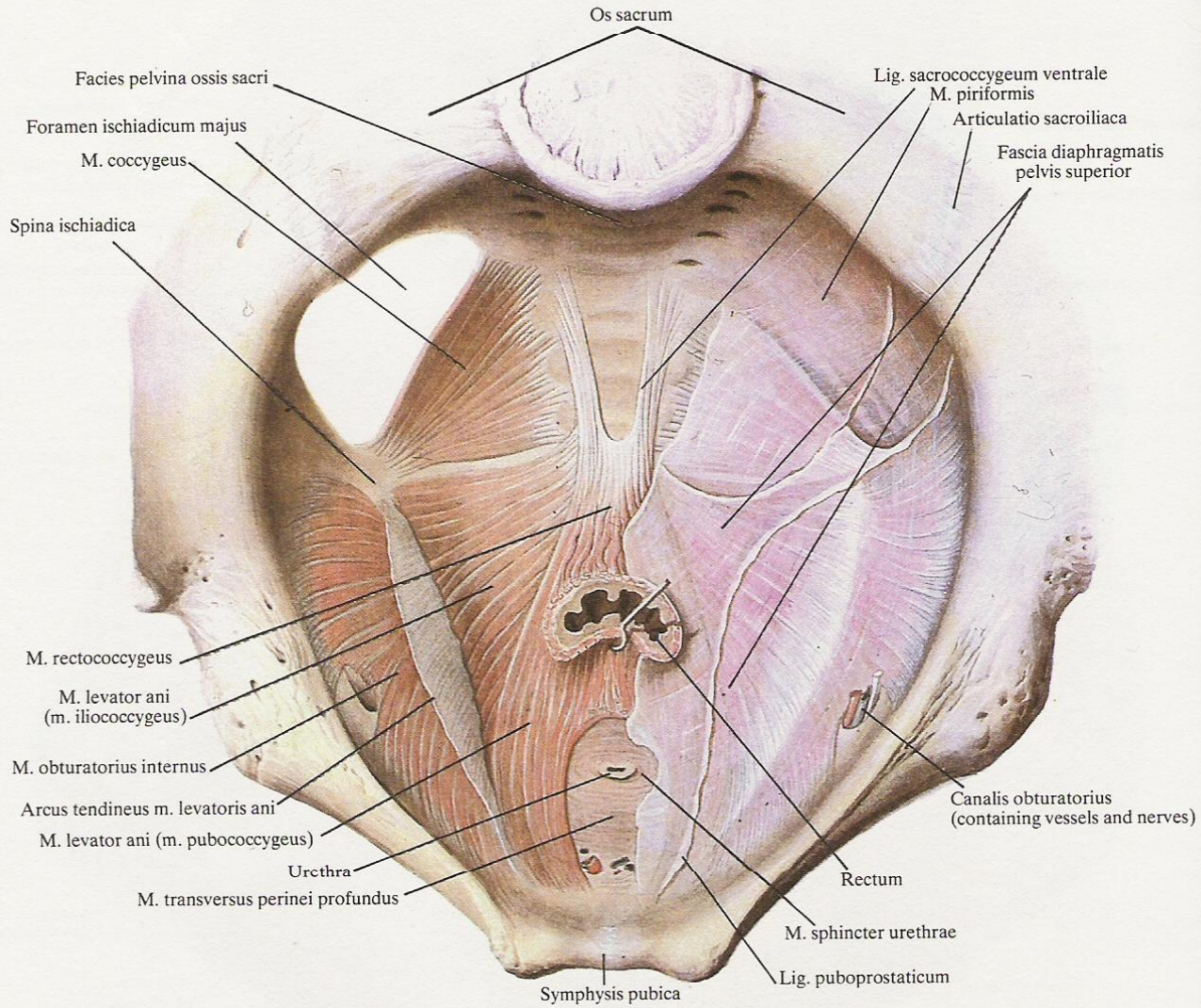


576. *Muscles and fasciae of female perineum;* inferior aspect (¾).
(The fasciae are removed on the left.)

From the place of its origin the muscle runs backwards, downwards, and medially and is inserted into the anococcygeal body *(ligamentum anococcygeum)*, the anterior sacrococcygeal ligament *(ligamentum sacrococcygeum ventrale)*, and the anterior wall of the rectum; along its course it gives off part of its bundles into the sphincter ani externus muscle. At the level of the perineal flexure *(flexura perinealis)* of the rectum the right and left pubococcygeus muscles are inserted behind the rectum under the rectococcygeal muscle *(musculus rectococcygeus)*. The pubococcygeus muscle is related anteriorly to the urethra, and to the prostate in males and the vagina in females; it is fused with these organs as well as with the rectum and urinary bladder and sends into them fibrous bundles with an admixture of elastic and muscle fibres.

Action: the muscle is a constrictor for the most part—concerted contraction of the right and left pubococcygeus muscles brings the posterior wall of the rectum closer to the anterior wall, thus narrowing the distal part of the rectum (the anus takes the shape of a transverse slit), and raises and pulls it forwards and upwards together with the floor of the true pelvis. In females the muscle also constricts the vagina.

(b) The **iliococcygeus muscle** *(musculus iliococcygeus)* arises from the tendinous arch, to the back of the origin of the pubococcygeus



577. *Muscles and fasciae of floor of true pelvis in a male;* superior aspect (¾).

muscle. It runs backwards, downwards, and medially to be inserted into the coccyx below the pubococcygeus muscle. Its medial bundles form together with those of the contralateral muscle a common tendon stretching between the rectum and the apex of the coccyx. The lateral bundles pass to the lateral border of the coccyx. The iliococcygeus muscle is related posteriorly to the coccygeus muscle covering it superiorly.

Action: raises the floor of the pelvis and makes it more resilient and firmer.

2. The **coccygeus muscle** *(musculus coccygeus)* (Fig. 577) is a triangular sheet situated on the inner surface of the sacrospinous ligament; it originates by a narrow apex from the ischial spine, and its wide base is inserted into the lateral borders of the lower sacral and the coccygeal vertebrae. The anterior border of the muscle adjoins the posterior border of the levator ani muscle to form a continuous muscular sheet.

3. The **sphincter ani externus muscle** *(musculus sphincter ani externus)* (Figs 547, 562, 569, 575) is unpaired. It embraces the perineal (anal) part of the rectum distal to the pelvic diaphragm. Its upper bundles are in relation with the bundles of the levator ani muscle. Three parts are distinguished in the sphincter ani externus muscle: the **subcutaneous part** *(pars subcutanea)*, the **superficial part** *(pars superficialis)*, and the **deep part** *(pars profunda)*. Its medial portion is more powerfully developed and circular.

The lateral portion arises by a sharp posterior end from the posterior surface and apex of the coccyx, the anococcygeal body or

in the skin. It bypasses laterally the anal part of the rectum; anteriorly the lateral portion terminates by a sharp end in the tendinous raphe of the bulbospongiosus muscle and in the skin of the perineum. The bundles of the lateral part intersect behind and in front of the rectum.

A small part of the smooth muscles from the longitudinal bundle of the rectum join the striated fibres of the sphincter ani externus muscle.

Action: contraction of the muscle compresses the anus from the sides and makes it slit-like.

Innervation: the sacral and pudendal plexuses (*plexus sacralis* et *pudendus*).

Blood supply: internal pudendal and inferior rectal arteries *(arteriae pudenda interna* et *rectalis inferior)*.

THE FASCIA OF THE MUSCLES OF THE TRUE PELVIS

The **fascia of the muscles of the true pelvis** *(fascia pelvis)* (Figs 575–577) is a continuation of the intra-abdominal fascia and forms in the cavity of the pelvis the **parietal pelvic fascia** *(fascia pelvis parietalis)* and the **visceral pelvic fascia** *(fascia pelvis visceralis)*.

The parietal fascia lining the walls of the true pelvis is particularly pronounced in the region of the obturator (obturator fascia), piriformis, and coccygeus muscles. The parietal fascia arises superiorly from the arcuate line and is intimately fused with the lower borders of the pubis and ischia.

Along its extension from the lower part of the pubic symphysis to the ischial spine the parietal fascia is thickened by the levator ani muscle arising from this line and two fasciae covering it superiorly and inferiorly.

The thickened line of the parietal fascia is called the **tendinous arch of the levator ani muscle** *(arcus tendineus musculi levatoris ani)*; the fascia covering the levator ani muscle is also referred to the parietal fascia.

The fascia covering the superior (inner) surface of this muscle is known as the **superior fascia of the pelvic diaphragm** *(fascia diaphragmatis pelvis superior)*.

At the site where this fascia approaches the internal organs (the rectum and urinary bladder) it is thick and gives off layers which invest them, this is the **visceral pelvic fascia** *(fascia pelvis visceralis)*. The origin of the visceral fascia is called the **tendinous arch of the fascia of the pelvic muscles** *(arcus tendineus fasciae pelvis)*.

The visceral fascia envelops the bladder and rectum, in females also the vagina and in males the prostate, seminal vesicles, and the ampullae of vasa deferentia.

The part of the visceral fascia in front of the rectum and in males separating it from the prostate, seminal vesicles, and bladder is called the **rectovesical septum** *(septum rectovesicale)*; in females it separates the rectum from the vagina and is known as the **rectovaginal septum** *(septum rectovaginale)*. This fascia arises superiorly from the floor of the peritoneal pouch which separates these organs, and terminates inferiorly on the floor of the pelvis, due to which it is also called peritoneo-perineal aponeurosis.

The **inferior fascia of the pelvic diaphragm** *(fascia diaphragmatis pelvis inferior)* covers the lower surface of the levator ani muscle. It also arises from the tendinous arch of the muscle.

Thickenings of the fascia of the pelvic muscles form ligaments: the paired **puboprostatic ligaments** *(ligamenta puboprostatica)* in males and the **pubovesical ligaments** *(ligamenta pubovesicalia)* in females. They arise on the posterior surface of the pubic symphysis and stretch backwards to the prostate and bladder in males and to the urethra and bladder in females. Among the fibrous bundles forming these ligaments are bundles of smooth muscle fibres which are constituents of the pubovesical muscles *(musculi pubovesicales)*.

The levator ani muscle and the fascia covering it form the lateral and posterior parts of the floor of the pelvis; the lateral border of the floor passes on the tendinous arch of the muscle, the medial—on the tendinous arch of the fascia of the pelvic muscles lying on the median border of the levator ani muscle.

In front of the rectum, between the medial borders of the right and left pubococcygeus muscles, is an area free of muscles; it is closed inferiorly by the urogenital diaphragm *(diaphragma urogenitale)* which thus contributes to the formation of the floor of the pelvis.

The **superficial fascia of the perineum** *(fascia superficialis perinei)* is the most superficially located fascia of the perineal region which limits from below all the structures of the anal and urogenital regions described above (the fasciae of the urogenital diaphragm are described in the section *The Urogenital Diaphragm*).

The **ischiorectal fossa** *(fossa ischiorectalis)* (Figs 570, 575) is formed laterally by the ischial tuberosity and the fascia of the obturator internus muscle, and medially by the inferior fascia of the pelvic diaphragm; superiorly it extends to the place of origin of the levator ani muscle. This fossa is filled by the **ischiorectal pad of fat** *(corpus adiposum fossae ischiorectalis)* which transmits vessels and nerves invested in a fascial canal called the **pudendal canal** *(canalis pudendalis)*.

THE UROGENITAL DIAPHRAGM

The **urogenital diaphragm** *(diaphragma urogenitale)* like the pelvic diaphragm, is a musculofascial sheet which is situated in the anterior part of the true pelvis, between the inferior pubic rami and the rami of the ischia.

Its upper surface is formed by the **superior fascia of the urogenital diaphragm** *(fascia diaphragmatis urogenitalis superior)*, the lower surface—by the **inferior fascia of the urogenital diaphragm**, or the **perineal membrane** (*fascia diaphragmatis urogenitalis inferior*, s. *membrana perinei*) (Figs 576, 577); they are both fastened on each side to the inferior pubic ramus and the ramus of the ischium.

In front of the urethra the anterior border of the diaphragm does not reach the pubic symphysis but forms a dense and tightly stretched **transverse ligament of the pelvis** *(ligamentum transversum perinei)*.

The free space between the pubic symphysis, the inferior pubic ligament, and the transverse ligament transmits the deep dorsal vein of the penis *(vena dorsalis penis profunda)* or the deep vein of the clitoris *(vena dorsalis clitoridis profunda)*. The superior and inferior fasciae unite on the posterior border of the urogenital diaphragm to form its posterior boundary.

The superior fascia in males is fused with the sheath of the prostate *(fascia prostatae)*. Both fasciae are fused with the walls of the urethra, and in females also with the wall of the vagina.

Between the superior and inferior fasciae of the urogenital diaphragm is the **deep perineal space** *(spatium perinei profundum)* in which two muscles are lodged: the sphincter urethrae muscle *(musculus sphincter urethrae)* anteriorly and the deep transverse perinei muscle *(musculus transversus perinei profundus)* posteriorly.

Into the muscle in the deep perienal space are embedded the bulbo-urethral glands *(glandulae bulbourethrales)* in males and the greater vestibular glands *(glandulae vestibulares majores)* in females.

The muscles of the urogenital diaphragm and those of the external genital organs are the muscles of the urogenital region.

THE MUSCLES OF THE UROGENITAL DIAPHRAGM

1. The **deep transverse perinei muscle** *(musculus transversus perinei profundus)* (Figs 569, 576) is a paired, narrow, and small muscle. It arises on the ischial tuberosities to the back of the site of insertion of the ischiocavernosus muscle and runs to the midline to unite with the contralateral muscle.

2. The **sphincter urethrae muscle** *(musculus sphincter urethrae)* (Fig. 577) is paired and lies in front of the deep transverse perinei muscle. Peripheral bundles running to the pubic rami and the fascia of the urogenital diaphragm, and central circular bundles lying deeper, around the membranous part of the urethra, are distinguished in this muscle. Besides, it is fused with the prostate in males and with the vagina in females. A few smooth fibres join the striated muscle bundles.

Action: compresses the urethra as well as the bulbourethral glands in the male and the greater vestibular glands in the female.

Innervation and blood supply: see *The Muscles of the Pelvic Diaphragm*.

3. The **superficial transversus perinei muscle** *(musculus transversus perinei superficialis)* (Figs 569, 575, 576) is inconstant and may be absent on one or both sides. It is situated at the posterior border of the urogenital diaphragm and is a thin muscular band stretching across the perineum.

Its lateral end is inserted into the ischium, the medial end intersects with the contralateral muscle along the median line and is partly interlaced with the bulbospongiosus muscle and partly with the sphincter ani externus muscle.

THE MUSCLES OF THE EXTERNAL GENITAL ORGANS

1. The **ischiocavernosus muscle** *(musculus ischiocavernosus)* (Fig. 575) is a paired narrow muscular slip. It arises by a narrow tendon from the medial surface of the ischial tuberosity, passes forwards inferior to the crus of the corpus cavernosum penis (clitoridis), and is lost on its dorsal surface in the fibrous coat. In some cases it unites on the dorsal surface of the penis with the contralateral muscle to form a kind of loop at its root. The posterior end is at the site of origin of the superficial transversus perinei muscle.

Action: compresses the superficial veins of the penis as a result of which stasis of blood occurs in the corpora cavernosa, which contributes to making the penis erect; in females its action is negligible.

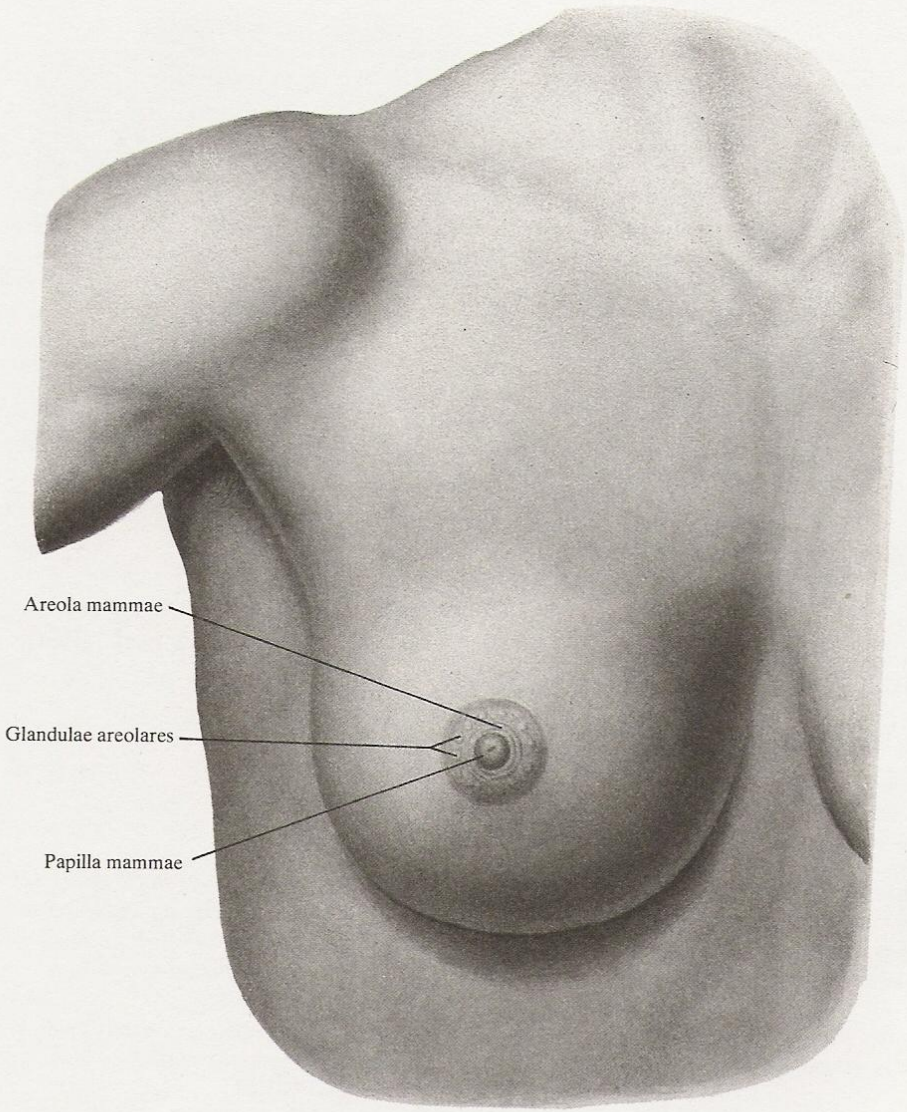
2. The **bulbospongiosus muscle** *(musculus bulbospongiosus)* (Figs 548, 575) is paired. It embraces the inferior and lateral bulging surfaces of the bulb of the penis up to the place of fusion of the corpora cavernosa. Posteriorly its bundles reach the sphincter ani externus muscle.

Three layers are distinguished in the muscle. The superficial layer arises from the fibrous raphe on the midline of the tunica albuginea of the bulb of the penis. The second layer begins from the transverse fibrous raphe formed by the posterior border of the fascia of the perineum. The third layer is the deepest and embraces the posterior part of the bulb of the penis.

The bulbospongiosus muscle terminates anteriorly in the fascia on the dorsum of the penis; posteriorly it is joined to the superficial transversus perinei muscle and to the anterior end of the sphincter ani externus muscle. The junction of the bulbospongiosus, superficial transversus perinei, and the sphincter ani externus muscles with the middle of the posterior border of the urogenital diaphragm is called the **perineal body** *(centrum tendineum perinei)*.

The bulbospongiosus muscle in females encircles the orifice of the vagina. After passing around it on both sides, the muscle runs forwards to be inserted into the tunica albuginea of the clitoris, on its superior and lateral surfaces; the posterior parts of the muscle are interlaced into the perineal body.

Action: compresses the bulb and corpora cavernosa of the penis and, with them, the bulbo-urethral glands and the deep dorsal



578. *Mammary gland (glandula mammaria) of female (2/5).*

vein of the penis. In females it constricts the orifice of the vagina, compresses the bulb of the vestibule, and the greater vestibular gland.

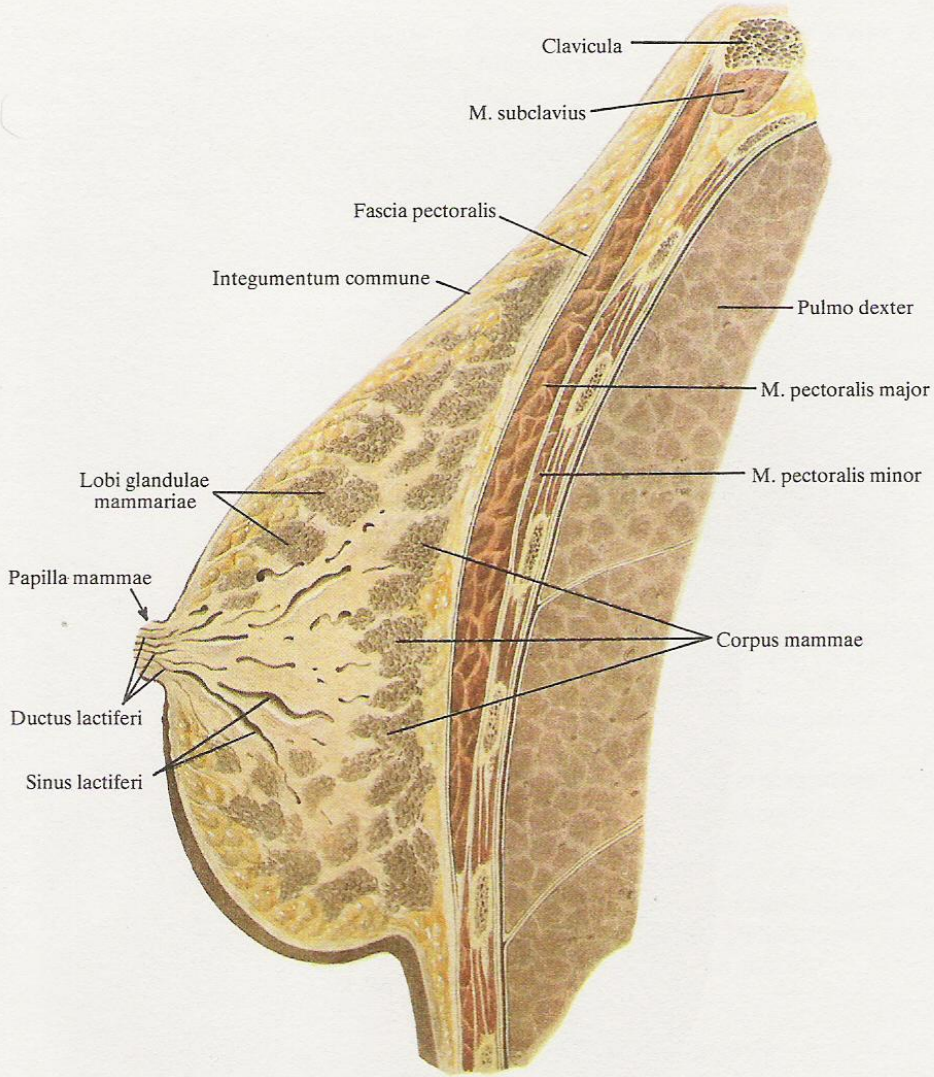
Innervation and blood supply: see *The Muscles of the Pelvic Diaphragm*.

THE MAMMARY GLAND

The **mammary gland** *(glandula mammaria)* (Figs 578–580) is situated on the anterior surface of the pectoralis major and partly the serratus anterior muscles in the space between the median and axillary lines and extends from the third to the sixth, sometimes the seventh, rib.

The mammary gland is surrounded by fatty tissue, which determines its shape. Its size and shape change considerably with age and in different functional conditions (pregnancy, lactation).

A depression is formed between the right and left breasts. The **areola of the breast** *(areola mammae)* is in the middle area of the



579. *Mammary gland (glandula mammaria) of female (⅔).*
(Sagittal section.)

gland, on the level of the fifth rib and slightly lateral to the mamillary line (*linea mamillaris* s. *medioclavicularis*) with the **nipple of the breast** *(papilla mammae)* in its centre. Both the areola and the nipple are pigmented.

The mammary gland is made up of the glandular, fatty and fibrous tissue.

The **body of the breast** *(corpus mammae)* is composed of 15 to 20 separate **lobes of the mammary gland** *(lobi glandulae mammariae)* which are surrounded by fatty tissue.

Each lobe has an efferent **lactiferous duct** *(ductus lactiferus)* which runs to the nipple and before entering it forms a spindle-shaped dilatation called the **lactiferous sinus** *(sinus lactiferus)*. The terminal narrowed part of the duct pierces the nipple and opens on its tip by funnel-shaped dilated lactiferous apertures. The number of the apertures varies from 8 to 15, and is less than the number of lobes because some of the ducts unite. Each lobe of the mammary gland and its body as a whole are covered by fatty tissue lending it a semispherical shape. Connective-tissue processes run from the anterior surface of the gland to the skin. The posterior surface of the gland is smooth and separated from the underlying fascia of the pectoralis major muscle by a layer of capsule. The connective-tissue capsule investing the gland fastens ("suspends") it on the clavicle and also sends septa between the lobes of the gland.